ISTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

ASSESSING GREEN DESIGN APPROACH TO DEVELOP A CONCEPTUAL MODEL FOR LANDSCAPE PLANNING IN UNIVERSITY CAMPUSES

M.Sc. Thesis by
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Department: Urban and Regional Planning

Programme: Landscape Planning

JUNE 2006

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ISTANBUL TEKNIK ÜNIVERSITESI ★ FEN BILIMLERI ENSTITÜSÜ

ÜNIVERSITE KAMPÜSLERINDE PEYZAJ PLANLAMASI IÇIN KAVRAMSAL BIR MODELIN OLUSTURULMASINDA YESIL TASARIM YAKLASIMININ DEGERLENDIRILMESI

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CONTENTS

ABBREVATIONS

BBC : British Broadcasting Corporation
BCIA : Building Controls Industry Associations
CAT : Centre for Alternative Technology
CEED : Community Environmental Educational Development
CFC : Chlorofluorocarbons
CIAM : International Congress of Modern Architecture
CIP : Civic Involvement Project
CSAF : Campus Sustainability Assessment Framework
DEFRA : Department for Environment, Food and Rural Affairs
DFEE : Department for Education and Employment
ECO : Environmental Coalition in UCB
ECTP : The European Council of Town Planners
EIA : Environmental Impact Assessment
EPA : Environmental Protection Agency
EU : European Union
GITP : Greening Ivory Towers Project
GSU : Georgia Southern University
HEPS : Higher Education Partnership for Sustainability
IAU : International Association of Universities
IISD : International Institute for Sustainable Development
IPM : Integrated Pest Management
ISO : International Organization for Standardization
ISTEK : Istanbul Education and Culture Foundation
IUCN : World Conservation Union
LRDP : Long Range Development Plan
NEAP : National Environment Action Plan (Ulusal Çevre Eylem Plani)
NO_x : Nitrogen Oxides
NUMBA : Nottingham University Management and Business Alumni
NUS : National University of Singapore
NWF : National Wildlife Federation
PETE : Partnership for Environmental Technology Education
PV : Photovoltaic
RIBA : Royal Institute of British Architects
QMUC : Queen Margaret University College
SO_2 : Sulphur Dioxide
SYC : Sierra Youth Coalition
UB : The State University of New York at Buffalo
UBC : University of British Colombia
UCB : University of California Berkeley
UCBC : University of California Berkeley Campus
UK : United Kingdom

ULSF : University Leaders for a Sustainable Future
UN : United Nations
UNCED : United Nations Conference on Environment and Development
UNEP : United Nations Environment Programme
UNFCCC : United Nations Framework Convention on Climate Change
UNSW : University of New South Wales
US : United States
USEPA : US Environmental Protection Agency
YÖK : Board of Higher Education (Yüksek Ögretim Kurulu)

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ASSESSING GREEN DESIGN APPROACH TO DEVELOP A CONCEPTUAL MODEL FOR LANDSCAPE PLANNING IN UNIVERSITY CAMPUSES

ABSTRACT

Population growth, water and air pollution, climate change, deforestation and species decline are some of the increasing environmental problems. Sustainability concept has been arisen from these environmental concerns in order to find long term solutions for environmental degradation. Various planning and design disciplines have been affected with this idea. Green Design concept has assisted environmentally friendly designs in order to achieve sustainability.

Universities have pioneer role in teaching and researching solutions to society's social and environmental concerns as well as serving as models in order to achieve sustainability in their communities. They can form educational areas, and promote environmental awareness and sustainability in their campuses.

This study explores how to design sustainable, environmentally friendly landscapes and implement green design in university campuses. Energy conservation, waste management, water management, pest management, sustainable landscape material, transportation, wildlife habitat preservation and landscape maintenance, educational gardens, environmental stewardship and monitoring subjects are examined as green design criteria throughout the study. These criteria for campus landscapes have been determined by a comprehensive research using variety of resources.

A conceptual model has been developed by introducing a campus planning method and green design guidelines for sustainable landscape planning applicable to most university campuses across the world. Therefore, two university campuses have been studied in relation to the existence of green design initiatives in their campuses. These university campuses are University of California Berkeley Campus and University of Nottingham Jubilee Campus. In addition, recommendations for implementing green design in campus landscapes have been developed for Yeditepe University Kayisdagi Campus in Turkey. This model is considered as a tool to achieve sustainability in landscape planning for universities within Turkey and across the world.

The major contribution of this study is its furthering of the understanding of the tools and methodology that can be used in green design applications for sustainable development in university campus landscapes.

ÜNIVERSITE KAMPÜSLERINDE PEYZAJ PLANLAMASI IÇIN KAVRAMSAL BIR MODELIN OLUSTURULMASINDA YESIL TASARIM YAKLASIMININ DEGERLENDIRILMESI

ÖZET

Nüfus artisi, su ve hava kirliligi, ve küresel iklim degisiklikleri, çöllesme ve türlerin yok olusu giderek artan çevresel problemlerdir. Sürdürülebilirlik kavrami bu çevresel sorunlari önlenmesinde ve etkilerinin azaltilmasinda uzun dönemli çözümler olusturmak amaciyla ortaya çikmistir. Çesitli planlama ve tasarim disiplinleri bu yaklasimdan etkilenmistir. Yesil tasarim kavrami da sürdürülebilirligi saglama amacini güderek çevre dostu tasarimlarin ortaya çikmasini saglamistir.

Üniversiteler toplumlarin sosyal ve çevresel sorunlarina çözümlerin arastirilmasinda ve ögretilmesinde öncü bir role sahip olduklari gibi kendi toplumlarinda sürdürülebilirligi saglayabilmek için model olarak hizmet ederler. Kampüslerinde ögretici alanlar olusturabilir, cevre bilincinin ve sürdürülebilirligin gelismesine yardimci olabilirler.

Bu çalisma sürdürülebilir çevre dostu peyzajlarin nasil tasarlanabilecegi ve yesil tasarimin üniversite kampüslerinde uygulanisini incelemektedir. Çalisma kapsaminda enerji koruma, atik yönetimi, su yönetimi, sürdürülebilir peyzaj materyali kullanimi, ulasim, dogal hayati koruma, peyzaj bakimi, ögretici bahçeler, çevre gönüllülügü ve denetim konulari yesil tasarim kriterleri olarak incelenmistir. Bu kriterler çesitli kaynaklar kullanilarak olusturulan kapsamli bir arastirma sonucu belirlenmistir.

Dünyadaki çogu üniversite kampüsüne uygulanabilir nitelikte sürdürülebilir peyzaj planlamasi için kampüs planlama metodu ve yesil tasarim ilkeleri olusturularak bir kavramsal model gelistirilmistir. Bu baglamda, iki üniversite kampüsü yesil tasarim çalismalarinin varligina göre irdelenmistir. Bu üniversite kampüsleri, California Üniversitesi Berkeley Kampüsü ve Nottingham Üniversitesi Jubilee kampüsüdür. Ayrica, Türkiye'de bulunan Yeditepe Üniversitesi Kayisdagi Kampüsü'nde yesil tasarim uygulamalari için tavsiyeler gelistirilmistir. Bu model dünyadaki ve Türkiye'deki üniversite kampüslerinin peyzaj planlamasinda sürdürülebilirligi saglayabilmek için bir araç olarak düsünülmüstür.

Bu çalismanin en önemli katkisi üniversite kampüs peyzaj alanlarinda sürdürülebilir gelisme için yesil tasarim uygulamalarinda yararlanilan araçlarin ve metodolojinin anlasilmasinin ilerletilmesidir.

CHAPTER 1. INTRODUCTION

Environmental issues such as climate change, greenhouse effect, water, air and soil pollution are today's most spoken of and rapidly increasing issues. There is a growing concern of these issues in all aspects of life. The research about the causes and prevention measures of environmental problems are very vital for the future of human life and ecosystems.

Environmental degradation is a major problem of present day as a consequence of existing way of life's production and consumption. Human beings have negative impact on the environment by misusing natural resources, causing deforestation and pollution, using land inefficiently and adding to or removing specific organisms from the ecosystems.

Understanding the economic and environmental benefits of protecting resources and preventing less waste and pollution is very important in dealing with environmental issues. This understanding and knowledge can be obtained by educational institutions that have foresight in a wide range of developments and have resources to educate people at all ages in various subjects by using their facilities thoroughly.

Educational institutions do have an important and crucial role in the progress of sustainable environmental development. Awareness of environmental issues has been growing within the further and higher education sector during the past decade. University is an institutional organization where young people are oriented for the future. It provides community to have social interaction, cultural, scientific and recreational activity areas for the whole city and its environs. Universities are often the first places to explore new initiatives. University campuses are expected to employ environmentally sustainable ideas and methodologies to be disseminated for better future development.

Most universities have campuses that contain large open areas with lawns, waterscapes, woodlands and other recreational areas. University campus, like a human body, is an organized composition with its own special anatomy. The landscape is far more than the space between buildings; it is the rational organization of outdoor spaces and everything that encompasses - pavements, walls, utilities, lightning, lawns, trees, water and other plantings (Yahres, 2006).

University campus design involves planning a physical environment which contains various functions and elements in the concept of visual, aesthetic and environmental values. Campus master planning and landscape planning are the important parts of campus design process. Landscape planning is an expanding field that addresses regional and strategic planning and design. It focuses on landscape and urban design on both in medium and large scale, for example parks, forestry, river valleys and coastal zones. It deals with issues such as restoration, conservation, habitat creation, urban infrastructure, landscape classification and environmental impact assessment. Campus landscape planning is one of the areas where landscape architects and planners may be involved with many other professions. It can give form, concept and identity to a campus space while improving sustainability.

University campuses have great potential for building environmental sensitivity and awareness by new design approaches, environmental stewardship programs and training courses. Most university campuses are located on large lands with both natural and built environment. They are also part of existing ecosystems. Therefore, they may have a significant role in improving and introducing sustainable development and environmentally friendly design for their communities as well as the citizens of the whole settlement where they are located.

Campus greens, parks, and forests have served many functions supporting social events, providing beautiful, contemplative spaces, and creating recreational areas. Today campuses are being considered as an active, living classroom where education about environmental concerns and their prevention counter-measures take place. A campus provides both an educational area for learning about the environment and a tool for its restoration and improvement. For instance, restoring the hydrologic balance within a campus significantly affects the quantity and quality of water

downstream in city water reservoirs, trout streams, and associated wildlife habitats (Franklin et al., 2003).

The benefits of environmentally sensitive landscaping are unarguably enormous: it can improve water, air and soil quality; provide habitat for wildlife; and protect biological diversity; save energy and money. There may be various kind of campus landscaping projects that are environmentally friendly such as reducing pesticide use, planting native vegetation, using recycled construction materials, using permeable pavement materials, and designing wildlife habitat areas. These approaches not only improve the environmental health of a campus, but also form a green design approach for its users and future generations.

Green design is the catch-all term for a growing industry trend within the fields of architecture, construction, landscape planning, interior design and environmental design. Also it refers to "sustainable design" or "eco-design". The broad principles of green design are fairly simple: choosing energy efficiency wherever possible; working in harmony with natural features and resources surrounding the project site; and using products that have low impact on environment or preferring recycled materials rather than new materials from non-renewable resources.

A ‘sustainable’ or ‘green’ campus is a college or university campus that seeks to develop and manage itself in an environmentally-friendly fashion by continually implementing best management practices. It aims to reduce its ecological footprint and mitigate environmental impacts. A green campus challenges itself to become a living classroom and a model for future sustainable societies through education.

Many higher education institutions around the world recognize their environmental impacts and try to reduce their impacts by implementing policies for sustainable development, green design and environmental management projects. Some colleges and universities are assessing their environmental impacts through campus assessments and monitoring programmes while they are greening their curriculum. Although some of them offer courses on environmentally responsible policies and practices, relatively few have applied their teachings and policies to their own campuses effectively.

Sustainable campus efforts and green design initiatives give an opportunity to use the campus to teach, showcase of progressive principles, and serve as a model for the community in general. Students, staff, faculty and administrators mostly take part in these initiatives for greening their campuses. Non-profit and governmental organizations, stakeholders, student groups and unions also assist colleges and universities in adopting environmental and sustainable projects, programmes and educational activities to achieve sustainable development. Consequently, a sustainable or green campus educates people from all walks of life and sets best practices for future while improving the environment.

1.1 Structure of the Study

The study comprises four steps including the history of campus planning and sustainability, green design applications in campus landscapes, examples of green design initiatives in two university campuses, developing a conceptual model for landscape planning in campuses and recommendations for Yeditepe University Kayisdagi Campus as a case study.

Sustainability concept emerged as a result of increasing environmental problems. Green design concept has been evolved for sustainable development in campuses as a result of sustainability influence in planning. Initially green design is mostly related to building design, interior design and material selection; however, this study looks at green design from landscape design and planning standpoint. Accordingly, criteria of green design applications in campus landscape are grouped in two dimensions; physical and social. Each criterion is examined by providing examples from university campuses. Figure 1.1 shows the framework of the study.

The first chapter comprises introduction part including structure of thesis, objectives and methodology. The second chapter of the study evaluates the theory of campus planning history by giving examples of first university campus plans. After, environmental problems that we are facing today and the emerging concepts of “sustainability” and “green design” in campuses have been discussed.

In the third and fourth chapters, green design issues in university campus areas are discussed with landscape design, planning and management approaches that are

becoming an essential part of sustainable development. The third chapter evaluates physical dimensions of green design for sustainable development while the fourth chapter examines the social dimensions. In these chapters, the criteria related to green design have been determined and defined comprehensively. For each criterion, various universities in the world have been given as examples.

In the fifth chapter, two university campuses are assessed as best practices. Each campus landscape was analyzed in relation to green design initiatives and their effectiveness. A table showing the projects and goals to provide sustainability in campus landscapes by implementing green design has been created for each university campus. Additionally, planning activities, monitoring and management in these campuses have been assessed.

On this basis, the last chapter of this study contains a conceptual model for landscape planning with green design approach in university campuses for sustainable development by proposing a campus landscape planning method and determining green design guidelines. Finally, the guidelines and methods improved in this part are used for developing recommendations for implementing green design in Yeditepe University Kayisdagi Campus.

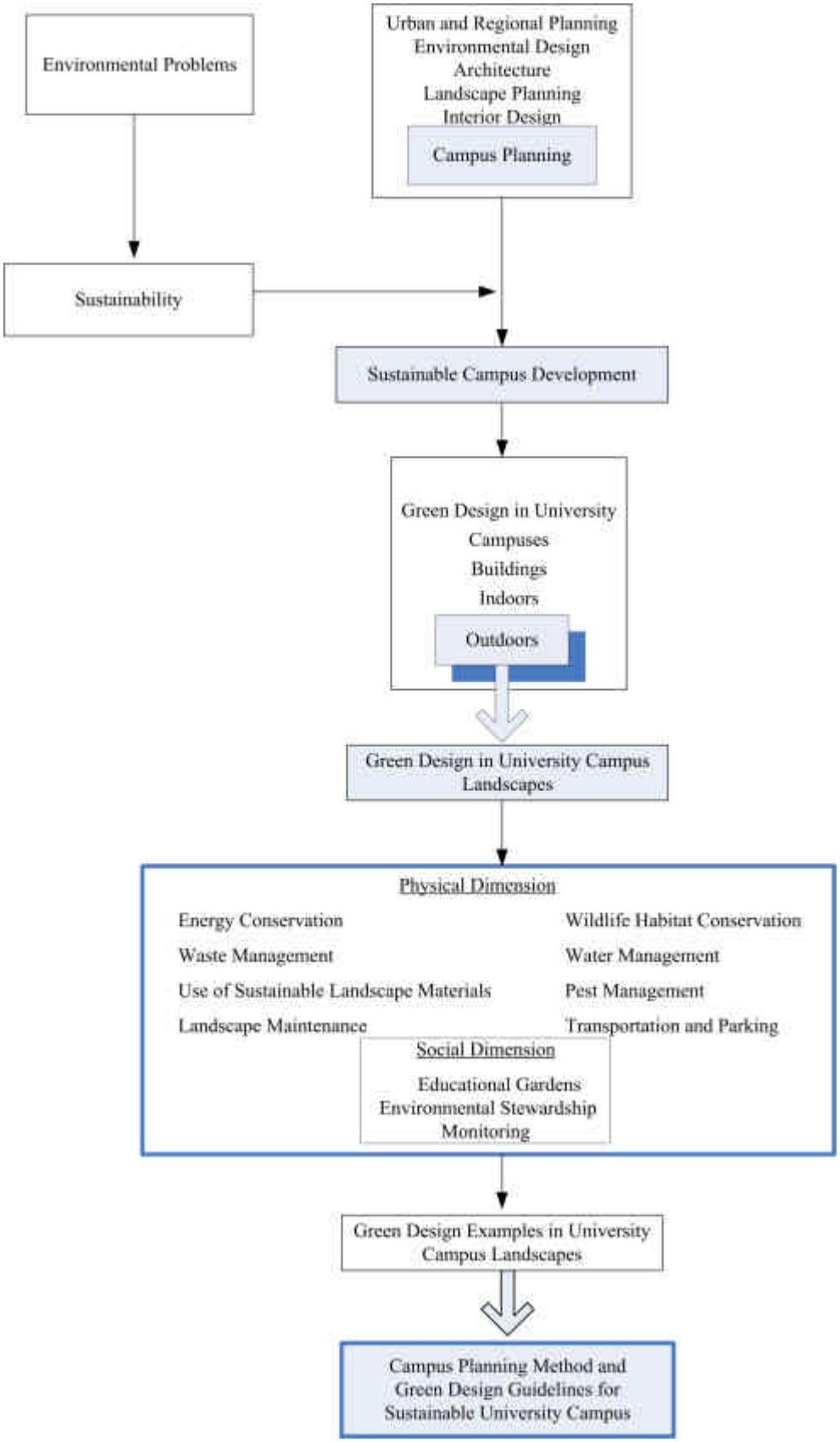

Figure 1.1: Framework of the Study

1.2 Objectives and Method of the Study

This study focuses on how to design sustainable, environmentally friendly landscapes and implement green design by assessing current green design applications in university campuses. Several criteria related to implementation of green design in campus landscapes have been assessed. These are energy conservation, waste management, use of sustainable landscape materials, water management, wildlife habitat conservation, pest management, landscape maintenance, transportation and parking, educational gardens, environmental stewardship and monitoring.

Finally, this study aims to develop a conceptual model by introducing a campus planning method and green design guidelines for sustainable landscape planning applicable to most university campuses across the world. Therefore, two university campuses, University of California Berkeley campus and University of Nottingham Jubilee Campus, have been studied as best practices in developing sustainability in their campuses. In addition, Yeditepe University Kayisdagi Campus has been chosen as a case study in order to develop recommendations for implementing green design in campus landscape.

The methods used in this study were established to observe, evaluate, and assess green design initiatives in campus landscapes for sustainable development by using literature, internet searches, articles, magazines, newspapers, site visits, personal interviews, campus plans and assessments. Historical review of campus planning, environmental problems and concerns, and sustainable development are parts of the study.

'Green Design' term which is commonly used for building design, interior design and use of materials in construction has been interpreted for campus landscape planning in this study. Criteria for green design applications in campus landscapes have been determined by a comprehensive research using variety of resources. These criteria are examined in two dimensions; physical and social. Energy conservation, waste management, water management, pest management, sustainable landscape material, transportation, wildlife, habitat preservation and landscape maintenance are grouped as physical improvement criteria. Relatively, educational gardens,

environmental stewardship and monitoring are grouped as social improvement criteria.

Examples of green design applications in university campuses are collected and compiled from official web sites of universities and related institutes, articles from newspapers and magazines, personal interviews, books, campus journals, plans and assessments.

The information related to Berkeley Campus has been obtained from the Campus Master Plan, Long Range Development Plan, Landscape Plan and Campus Sustainability Assessment. Jubilee Campus has been visited and assessed according to the information obtained by personnel communications and documents sent by campus planning team. Site analyses have been executed for Kayisdagi Campus. Environmental Impact Report, settlement plan, and future projects' details have been obtained from personnel communications.

As a result of the research, a model for landscape planning with green design approach in university campuses for sustainable development has been developed. A campus planning method and green design guidelines have been created for this conceptual model and these are used for developing recommendations for implementing green design in Yeditepe University Kayisdagi Campus.

CHAPTER 2. UNIVERSITY CAMPUS PLANNING AND SUSTAINABILITY

> *"The Greeks had their agora, the Romans their Forum, the Middle Ages their cathedral and town square, the Renaissance their palaces and enclaves for the privileged, and the 19th century their centres of commerce, transportation and government. The campus is uniquely our generation's contribution to communal placemaking and placemarking" (Dober, 1992, p.280).*

Campus is a Latin word for "field" or "open space" and English language gets the words "camp" and "campus" from this origin. Campus is a college or university site, an area of land that contains the main buildings and grounds of a university, college, or school (Microsoft Encarta, 2006). University is an undergraduate and postgraduate educational institution, an educational institution for higher learning that typically includes an undergraduate college and graduate schools in various disciplines. College is an institution of higher education created to educate and grant degrees; often it is a part of a university (Oxford English Dictionary, 2003).

University campus or single-site university which has teaching, administration, and dormitories located on one main site, usually a rural site, as opposed to being spread around different sites throughout a town (Microsoft Encarta, 2006). A university campus consists of open spaces as well as buildings. The architectural design for both buildings and campus green is strongly connected to a plan called "Campus Master Plan" which contains the whole campus area. A campus plan can define the institution's place within the larger community, justify land ownership, adjudge site location decisions, solve conflicts in land uses and circulation systems, and rationalize the construction and extension of infrastructure and be a good exemplar to its community (Dober, 1992).

The Latin term "campus" describes the distinctive physical character of American universities. It was first used to describe the college grounds, but gradually came to mean the entire property, including buildings, and later became the synonym for all university compounds. The romantic idea of isolation of campus from the city and

civilization came to its pure expression in the American college, located in nature and "removed from the corrupting forces of the city" (Turner 1990, p. 12).

In the first sections of this part, the evolution of universities and first appearances of campuses in western countries and Turkey will be examined. How the campus concept has emerged, how universities are affected by the built environment while they are affecting the nature and types of campus planning followed by universities will be explained. Campus landscape planning and campus master plans will be defined in the third section of this part. Finally, how and when green design concepts emerged and which universities in the world are implementing environmentally friendly designs and sustainability policies in their campuses will be evaluated in the last section.

2.1 Historical Evolution of Campus Planning in Western Countries

Although higher education existed in ancient times, its institutionalization is attributed to the Middle Ages. Universities initially emerged as institutions in Paris and Bologna at the end of the 11th century. They evolved from the cathedral schools and continued the tradition of the preservation of knowledge that had previously been the responsibility of monasteries. The university remained relatively unchanged from the Middle Ages until the late 18th and early 19th centuries, when religion gradually lost its dominant force and the European universities became institutions of modern learning and research. At the beginning of the 20th century, the number of universities increased throughout the world. Their organizational structures changed as additional fields of knowledge gave rise to the division of universities into different faculties and departments (Hashimshony and Haina, 2005).

In Greek times the most important higher education institutions were Gymnasiums and Academias. Gymnasiums consist of atriums surrounded by classrooms with a sports field at the centre. The use of lawns to create outdoor spaces has its antecedents in ancient Rome where villa walls enclosed pleasure gardens, some of which used ornamental grasses. These ground plans informed idealized concepts for the monasteries that emerged as educational centres in the dark ages. The monastic landscapes were developed to supply flowers for altars, vegetables for the kitchen,

and healing herbs for physicians. The space was crossed like a campus quadrangle, as monks walked to and from refectory, school, church, and work (Dober, 1992).

By the 6th century, after the acceptance of Christianity as an official religion, many schools teaching law, religion and philosophy were established around churches or cathedrals in Europe especially in France, Germany, and England.

In the Medieval Era, University was about a single building in city. In most of the Medieval Era cities, education remained inside churches and their courtyards. Courtyards played an important role in providing space for symbolic and mystic games, commercial and educational use (Laurie, 1986).

The first universities considered as the prototype of today's universities were founded at the end of 11th century in Europe. Among them, Bologna University was officially established in 1088, having started education with the school of law in 890. The first college to be built was probably Merton College at Oxford, founded in 1264. Its distinct architectural structure, formed by a square unit surrounding and an internal court, reflected its social and educational character (Hashimshony and Haina, 2005). After 13th century, the physical structure of the universities gradually began to change. Walls surrounded the outer borders and the concept of 'City University' progressively changed into a 'University City' (Kolac, 2002).

In 1746, with wide green areas around its buildings, Princeton University increased the inclination for creating green open spaces in American college planning, and the campus definition was used for the first time. The Humboldt University of Berlin, founded by Wilhelm von Humboldt in 1809, in which modern standards of academic freedom were pioneered, is representative of modern learning and research trends. According to Hashimshony and Haina (2005), the German model of the university as a complex of graduate schools performing advanced research and experimentation had a worldwide influence in defining the role of the university in society, but not in offering a new, innovative design.

The Kaiser-Wilhelm University in Strasbourg, designed in 1878 by Eggerth and Warth, demonstrates buildings within a park lined around a green rectangular block (Figure 2.1). This is seen as the first example of comprehending campus designs (Kortan, 1981 quoted in Kolac,2002, p.5).

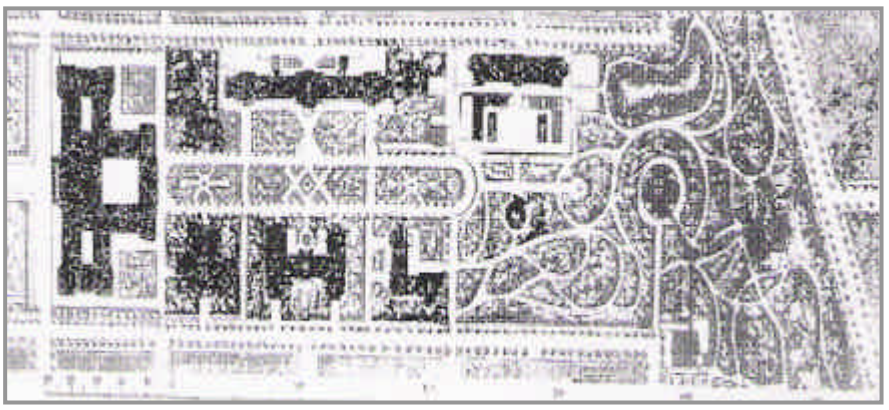

Figure 2.1: Kaiser-Wilhelm University in Strasbourg (Kortan, 1981 quoted in Kolac, 2002, p.5)

The most important development in the 19th century was the occurrence of new science branches and new faculties within university institutions. At the same time the 'University Extension Movement' was created in order to spread higher education to communities. The establishment of new universities followed this movement supported by Cambridge University.

During that period, campus designs in Britain were monumental, often symmetrical and neo-classic. Repetition of a number of courtyard college buildings created the whole university in time. Oxford and Cambridge (Figure 2.2) are good examples for this sense (Turner, 1995). A new system called Redbricks that connected colleges to academic centre, and dormitories took place in British universities. This was against the traditional buildings of Oxford and Cambridge, and was built in the industrial period with brick material. Durham (1832), London (1836), Manchester (1880), Birmingham (1900), Liverpool (1903), Belfast (1908), Sheffield (1905), Bristol (1909) and Reading (1926) were the universities established with this system (Suben, 1980).

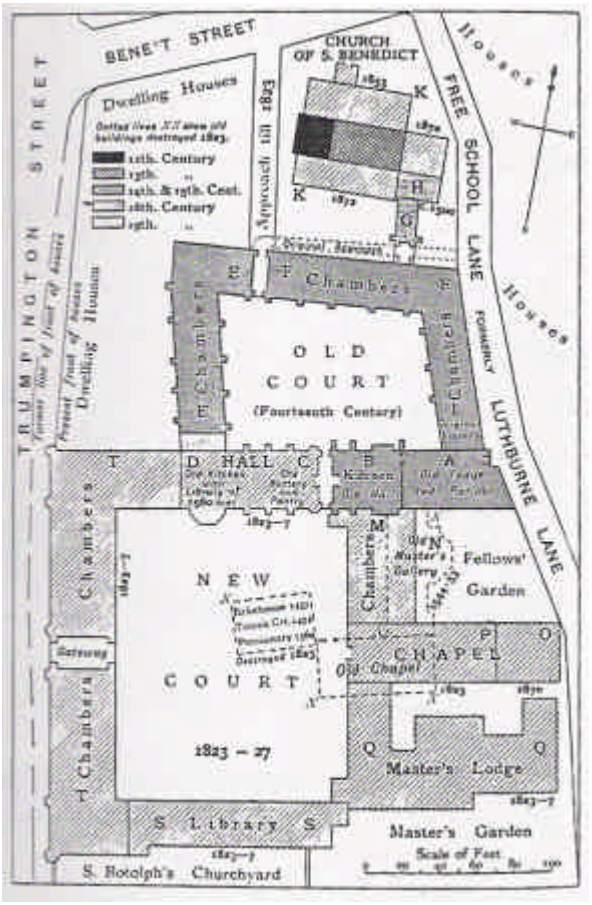

Figure 2.2: Christi College, Cambridge Campus (Turner,1995, p.10)

Oxford and Cambridge remained until the 19th century the only universities in Britain. In 1836, London University was established. "The first great revolution of university thinking came in that century with the establishment of London University and the civic foundations in the large population centres. London University has always been a special case, scattered widely across the metropolis, but its physical development shares certain features with the older civic universities such as Manchester, Liverpool, Leeds, and Birmingham" (Birks, 1972, p.9).

According to Dober (1968) the foundations of colleges in the United States has been explained as a desire by the colonists and determination of early settlers to preserve the Old World intellectual and cultural traditions. At first they sought to emulate the university models of Cambridge and Oxford, but the vastness of the land, long travel distances and general poverty made it impossible to establish a central university. In place of a single institution, nine colonial colleges were chartered between 1636 and 1780.

The earliest American institutions of higher education were Harvard University (1636), the College of William and Mary (1693), and Yale University (1701). The modern American university derives from three basic ideas: the English collegiate model, the German research university of the 19th century, and the American concept of service to society (Altbach, 1998).

New York University designed by Joseph Jacques Ramee in 1813 and Virginia University designed by Thomas Jefferson in Charlottesville (1817-1826) were the first examples of campus design in US, inspired from "Castrum" of Roman age. While designing the University of Virginia, Thomas Jefferson described his goal as the creation of an 'academic village' (Turner, 1990).

The first realized campus plan in the United States was prepared in 1813 by Joseph Jacques Ramee for Union College (Figure 2.3). In the years after 1865 the college lost ground to the university. Toward the end of the 19th century, journeys to Italy and France inspired the American designs, but Britain became the stronghold of campus architecture (Dober, 1968).

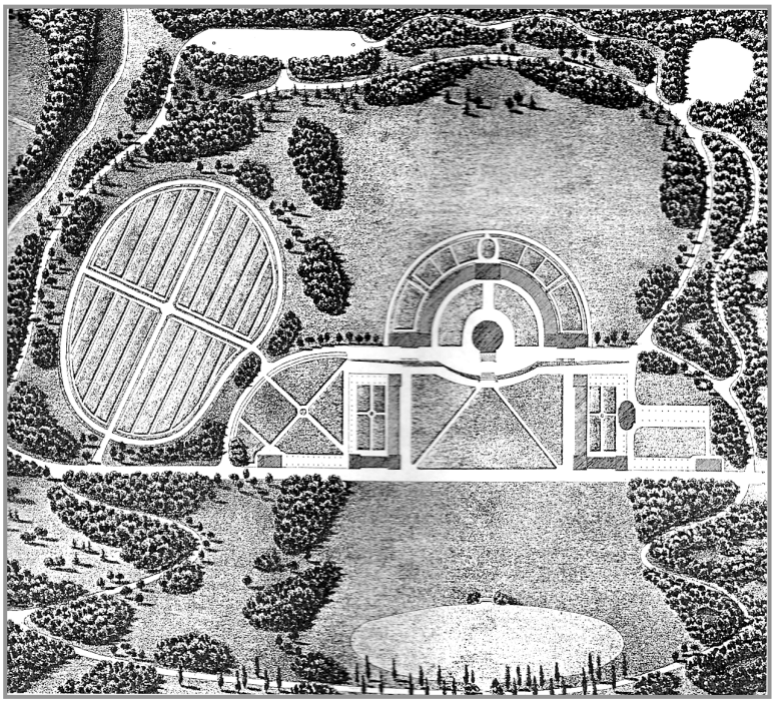

Figure 2.3: Site Plan for Union College by Joseph Jacques Ramee, 1813 (Turner, 1995, p.69)

Most American Colonial Colleges simply dropped their buildings on a green mat, precedence for the open campus plan. Thomas Jefferson's campus design for Virginia University differed in this regard, being a U-shaped grouping of connected buildings facing five grass plots bordered with trees (Figure 2.4). "Grass, trees, and fencing constituted the first landscapes of America's first colleges. Woodland areas cut back, nature tamed, and the site organized for institutional habitation and buildings. The greens are hoary symbols, such as Harvard Yard, or the Lawn at Charlottesville, Thomas Jefferson's signature landscape at the University of Virginia"(Dober, 1992, p.185).

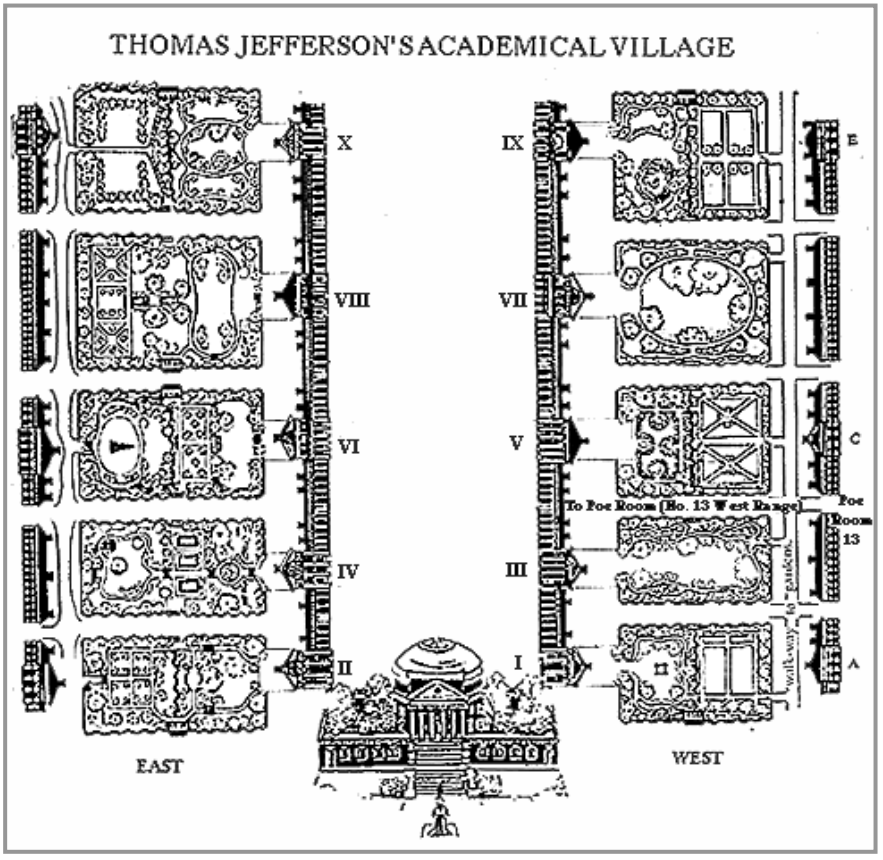

Figure 2.4: Virginia University Plan by Thomas Jefferson, Charlotteville

For almost two hundred years, Jefferson's University "Academical Village" has been the most compelling image of American social, political, and academic ideals. Dennis (1995) believes that the representation of his idea is still as strong and clear as a Mozart composition. Jefferson's plan was consistently completed after his death. It generated little influence until the end of the 19th century or shortly thereafter. Between 1890 and 1915, however, small sometimes heterogeneous colleges began to

transform into large, complex, modern universities, and many new universities were founded. This required a vision, a plan, and a process, and these were provided by the American extension of the French Beaux-Arts, the "City Beautiful" movement.

Universities were inside the borders of the city by 20th century. The location of the universities in cities was the result of their social structure. In this period, space for university expansion within city boundaries was more plentiful than it is today. A single building represented the university. However, due to new requirements and no space around, the new faculties emerged throughout the city. As a result, students had to travel vast distances and waste energy. In Italian and British Universities these problems were observed, and around 1930's universities were re-planned as a whole in the hinterland of the city.

In the 20th century, finding a suitable place for a University campus in the city became a problem. During the process of campuses locating outside city, countless American campuses were formed. The act of placing of colleges in the countryside or even in the wilderness was a unique break with European tradition. The romantic notion of a college in nature became an American ideal. But in this process, the university had to become even more fully a kind of miniature city. And its design became an experiment in urbanism (Turner, 1990).

Most of the designs in this period were highly unified compositions. One example of a highly unified design was Henry Hornbostel's reinterpretation of Jefferson's plan for Carnegie Institute of Technology (now Carnegie Mellon University) in 1904. Another, more city-like, example was Cass Gilbert's 1910 plan for the University of Minnesota, a large portion of which was carried out. Both of these campuses suffered greatly from thoughtless post-war additions, but the strength of their cores allowed them to survive (Dennis, 1995).

Some of the most picturesque college campuses in the United States were designed by Frederick Law Olmsted who is often called the father of American landscape architecture. He was presumably the first campus designer to identify the importance of natural topography. He took a practical approach, looking at the existing landscape, vegetation, and climate (Craven, 2005). Functional organization, urban design, landscaping, gardening, and art combined in Olmstead's campus designs.

One of Olmsted's earliest campus projects was to create a master plan for the College of California on a dry hill in Oakland. He wanted the college to blend with the character of the neighbourhood, and also to allow for later expansion. For these reasons, he argued for a picturesque rather than a formal plan (Figure 2.5). He placed the college buildings four miles away from Oakland's orderly, square village lots, and he divided the land into large wooded areas with tranquil winding roads. The 1865 plan proved flexible years later, when the College merged with another school to create the University of California, Berkeley. The resulting campus design, completed in 1914, does not entirely reflect Olmstead's original vision (Craven, 2005).

Figure 2.5: The Olmsted Plan for the College of California, 1865 (UCB Campus Landscape Heritage Plan, 2004)

Frank Lloyd Wright was one of the most well-known American architects of the 20th century. Wright believed that any architectural design has to make people more aware and respectful of their surroundings and of nature. Taliesin West campus was designed by him in 1937, and built over many years by apprentices who were a part

of the resident Taliesin Fellowship. The buildings of Taliesin West campus (Figure 2.6) with the designs of respect to nature rest on 600 acres of preserved Sonoran Desert on the South foothills of the McDowell mountains, and the whole campus is a compound of angular buildings, concrete walls embedded with quartz, redwood roofs and translucent ceilings letting in the natural light (Frank Lloyd Wright Foundation, 2006).

Figure 2.6: Taliesin West campus (The Frank Lloyd Wright Foundation, 2005)

The University campuses in this period benefited not just from one plan, but from a series of plans. The University of Illinois, for example, had at least thirteen plans in nine years between 1905 and 1914. The official Plan for the Development of the Campus, by Charles A. Platt, was adopted in 1922 and revised in 1927.

The emerging campus concept in American universities changed the view of other universities and their managements on how universities are planned. It is accepted that like cities and towns, universities should be planned considering their social, environmental and physical attributes.

Since campus design has similarities with urban design, urbanism has influences on campus designs as well as architectural innovations. In 1933 International Congress of Modern Architecture (C.I.A.M) manifesto had important determination about functional urban concept and also influenced campus designs (Kortan, 1981).

The Brazil University City was planned by Le Corbusier in 1936 according to decisions taken in C.I.A.M meeting in Athens (1933). The manifesto was created which pretended to be a definitive account of the spatial problems of the contemporary metropolis. The solution was zoning, a sharp distinction between dwelling, working, leisure and transport between them. Athens Charter (La Charte d'Athenes) protected its validity in planning from the beginning of 1930s to the end of 1950s.

In the 1940's, modern architecture began to influence campus designs. Modern architecture offered a vision of progress, promise, and newness and after the Second World War some campuses were built with that new norm.

25 years after C.I.A.M, zoning principles were criticized by a group of architects called Team-X. They had been arguing for human values against the arid dictates of CIAM. They were against the idea of zoning (Davey et al., 2005). They believed the structure of city that should give importance to humanistic relationships. At that time most campuses were designed with the influence of this opinion

After 1950 through to the present time, the developments in planning towns, cities, parks, and neighbourhoods had their counterpart on campuses. The rapid growth of colleges and universities was sufficient in scale and magnitude to give campus planning a visible, central and productive role in determining the physical forms of institutional life (Dober, 1992).

2.2 Historical Evolution of Campus Planning in Turkey

From the time that Turks settled in Anatolia until Republication, "Medrese" was the only form of education. 'Medrese' was placed in a 'Külliye' which was a complex building composed of a mosque, university, hospital, a primary school, kitchen, guest house and shops (Figure 2.7). All these buildings were arranged symmetrically around the mosque which is at the centre of the complex (Benli, 1998).

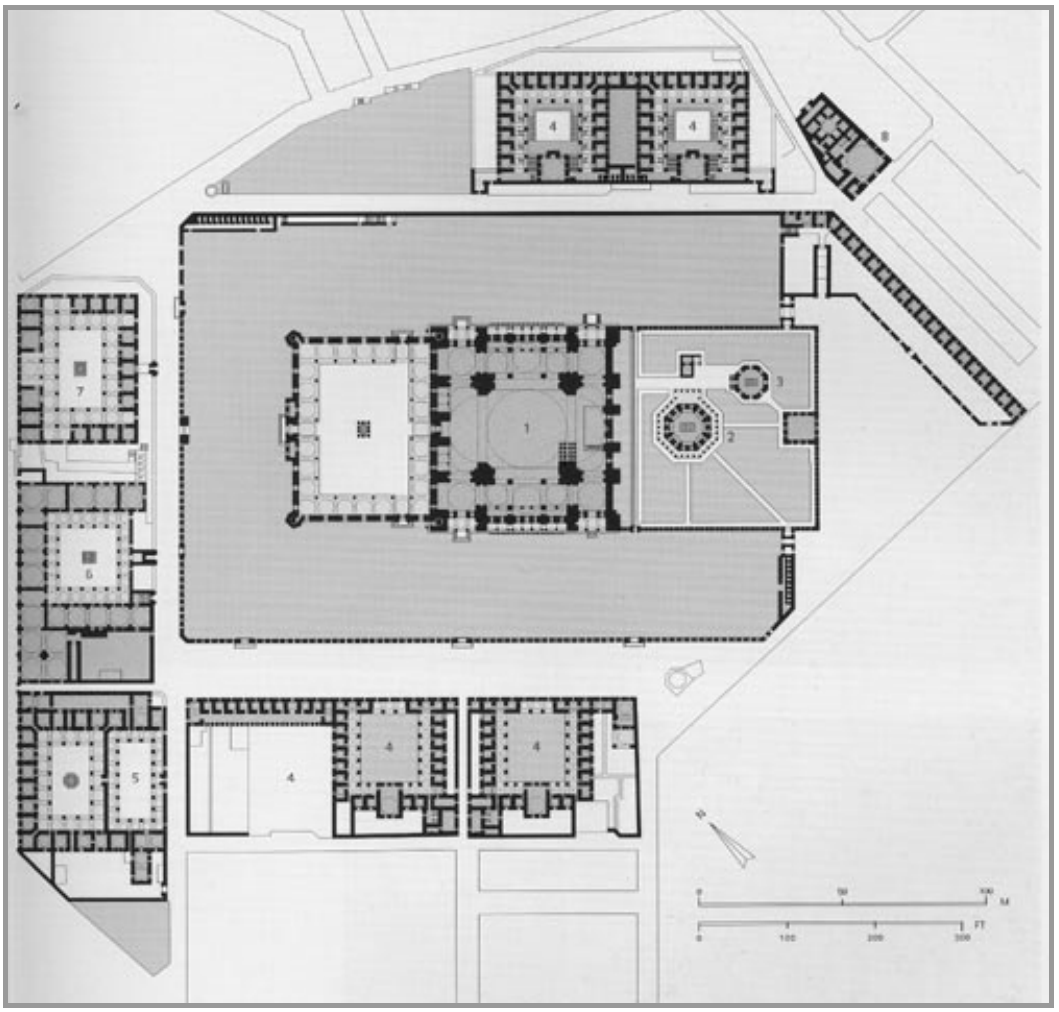

Figure 2.7: The külliye of Süleymaniye Mosque plan, Istanbul (Turkish Cultural Foundation, 2006)

Medreses in Seljuk and Ottoman periods have similarities such as they have both open courtyards surrounded by classrooms and other facilities in a wide area. These structures mostly contained a pool in the middle of the courtyard as well as some trees for shading (Çinar, 1998).

In the late Ottoman period, city universities with single buildings emerged. The Faculty of Medicine in Istanbul (now Marmara University Faculty of Medicine) established in 1903. This building has an open inner courtyard with classes facing outwards while the corridor opens onto the courtyard.

The first example of university campus design in Turkey was in 1950s. Erzurum Atatürk University (1957) was the first university which had a campus plan selected by a competition. The facilities and buildings are scattered across the campus. The

campus design is unable to adapt properly to its environment. A road crossing the campus site separates academic buildings from housing and recreational areas. Karadeniz Technical University Campus, built in 1963, is the second example of campus planning in Turkey. The scheme consists of separate buildings which are situated in a green area and all campus functions are distributed on the campus site.

In 1970, Istanbul Technical University Ayazaga Campus was designed as a suburban campus. Most of the faculties, student residence halls, recreational areas and the library are scattered throughout the campus area. The amenities, houses, faculty buildings and entrances are distant from each other. Vehicle usage is very high and there is no public transportation inside the campus despite it being scattered over a large area. Another campus planning application in 1973 was the establishment of Middle East Technical University Campus in Ankara (Benli, 1998).

Several projects were completed after the decision of investing in higher education during 1946 to 1973 and 1973 to 1981. With this new vision, it was realised that universities must be built outside of the cities and therefore they should be self-sufficient. Finally, Turkey felt the need for university campuses that would fit within the physical and social envrionment which encourages scientific and cultural relations within its communities. Bilkent, built in 1984, is the first university to apply the rules and regulations set by the government that clear the way for the non-profit organisations to provide higher education. Today, Turkey has 53 public and 19 trust universities (YÖK, 2006). The following table (Table 2.1) lists some of the universities established in Turkey chronologically;

Table 2.1: Establishment years of University campuses in Turkey (YÖK, 2006 and Benli, 1998)

Establishment Year	University	Location
1957	Erzurum Atatürk University	Erzurum
1963	Karadeniz Technical University	Trabzon
1970	Istanbul Technical University Ayazaga Campus	Istanbul
1971	Bogaziçi University	Istanbul
1973	Middle East Technical University Campus	Ankara
1973	Çukurova University	Adana
1973	Anatolia University	Eskisehir
1975	19 Mayis University	Samsun
1982	Yildiz Technical University	Istanbul
1984	Bilkent University	Ankara
1992	Koç University	Istanbul
1996	Istanbul Bilgi University	Istanbul
1996	Sabanci University	Istanbul
1996	Yeditepe University	Istanbul

2.3 Campus Landscape Planning

Campus landscape refers to the total complex of physical elements within the campus and evolves as a result of interaction between man, and "nonhuman" nature. It includes not only living plant materials (lawns, trees, shrubs and ground covers) but also all exterior site development such as ground surfaces (paving, concrete) and grading and land forms. Landscape may have a combination of natural surfaces, including ponds, and hard surfaces such as paves, sidewalks or brick patios. Additional to aesthetic and functional aspects of campus landscape design, it has environmental and security aspects that can reduce noise, control dust, divert traffic, secure boundaries, afford privacy and mitigate disaster risks-floods, erosion, snowfalls etc. Every university campus has its own ecological system based on its climate and ecosystem relationship. Differences in climate, sun-shadow patterns, soil, topography and plant selection are fundamental factors that have influence on the size, appearance, and quality of the campus natural environment (Dober, 1992).

"A campus without landscape is as likely as a circle without circumference, an arch without keystone, an ocean without water" (Dober, 1992, p.167). Traditionally campus landscape is seen as a green carpet upon which buildings are placed, or it is articulated as a device to extend a building design concept into open space (Dober, 2000). Most University campuses have significant land devoted to lawns, greens, and sports fields due to the requirements of the institution. The open spaces between buildings have aesthetic, functional and symbolic purposes. Campus landscape can serve as the skeleton for the overall campus plan, the interior circulation systems such as pedestrian and vehicle roads (Dober, 1992).

The primary objective of campus landscape planning is to make decisions about the use of resources. Campus landscape plans offer land uses and connections between buildings, open spaces, parking and transit, recreational areas, and infrastructure. Campus landscape planning process includes many important activities such as Long Range Development Plans, Campus Master Plans, Campus Landscape Plans, and Environmental Impact Assessments.

The Long Range Development Plan (LRDP) provides the overall planning framework for campus development in a long period of time from 10 to 20 years. Campuses prepare LRDPs based on their academic goals and the projected number of students for an established future date. Each LRDP indicates how a campus will accommodate the population along with the faculty and staff required to support that student population (University Of California, 1996).

Environmental Impact Assessment (EIA) evaluates the impact of the proposed development. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers.

A Campus Master Plan is a comprehensive plan that describes and maps the overall development concept for a campus, including present and future land use, detailed urban design and landscaping, infrastructure and service provision. Campus Landscape Master Plan provides the overall guidance for landscape projects to assure campus-wide physical and visual coordination. In particular, it defines major

landscape principles of the campus design, as well as potential sites for future development. Briefly, a master plan provides a strategy for universities' missions, goals and objectives.

2.4 Emerging Green Design Concepts and Sustainability in University Campuses

Throughout history, humans have depended on the natural environment. In the days before technology, people used natural resources to provide food, water, shelter and comfort. For instance, orienting buildings in relation to the sun helped people get through the year by providing heat during winter. In the last century, although technology freed people from most of the restrictions imposed by climate and the natural environment; it threatens the very systems on which people depend for air, food, and water (Anderson, 2006). In this manner, green design initiatives have emerged to find new solutions in order to conserve natural resources and protect ecosystems.

There are sufficient opportunities for scientists, architects, planners and designers to design products, buildings and landscapes that are environmentally sensitive. There are many things that can be done to prevent environmental issues. Green design is one of the practices that provide environmentally friendly options for architecture, landscape architecture, urban design and environmental planning.

Green design is environmentally responsible design that cares about its effect on people and the environment. It embraces a sustainable approach when designing buildings, interiors and landscapes. Green design aims to create healthier environments for people and all habitats. It is committed to conserve energy and water, generate less pollution, manage waste, and use materials with lowest environmental impacts. For instance, using products powered by alternative sources of energy and producing nearly zero waste or utilizing used materials are environmentally sound options. In addition, it attempts to reduce impacts on both developed and undeveloped land.

Green design or sustainable designs serve as tools to achieve sustainable development. Sustainability has been defined in many ways, but Our Common

Future, the 1987 report of the United Nations World Commission on Environment and Development gives the most enduring definition as “development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs” (Vardy, 2001).

In this part, the history of environmental issues and sustainability will be discussed in order to understand how sustainability and green design concepts have emerged. In addition, sustainability in university campuses will be assessed.

2.4.1 History of Environmental Issues and Sustainability

Like nature itself, every human-being has an impact on the planet’s ecosystems. Today, humanity's ecological footprint is over 23% larger than can be regenerated by the planet (Global Footprint Network, 2006). William Reese and Mathis Wackernagel developed the Footprint Analysis as an indicator of the combined ecological effects of per capita consumption and population growth. An Ecological Footprint is a measure of the load placed on the part of the earth and its atmosphere by a given population (Wackernagel et al., 1997). It is calculated in terms of the area of land and water appropriated for energy and resource consumption, and for waste disposal. The main causes of environmental issues are changes in human population, economic activity, and technology, as well as socio-political and cultural factors. For example, world population has doubled in the past forty years, with most of the growth taking place in developing countries (Green Facts, 2006).

An article titled Human Domination of Earth’s Ecosystems says “Between one-third and one-half of the land surface has been transformed by human action; the carbon dioxide concentration in the atmosphere has increased by nearly 30% since the beginning of the Industrial Revolution; more atmospheric nitrogen is now fixed by humanity than by all natural sources; more than half of all accessible surface fresh water is put to use by humanity; and about one-quarter of the bird species on Earth have been driven to extinction. The rates, scales, kinds, and combinations of changes occurring now are fundamentally different from those at any other time in the history”(Vitousek et al., 1997 quoted in Hill, 2004, p.1-2).

According to Spellerberg (1992), the rate at which species are becoming extinct as a result of exploitation is at a level never before witnessed. Myers (1983, quoted in Spellerberg, 1992) has suggested that an extinction rate of at least one species a day would not be unrealistic, possibly one every hour. Ecosystem processes, including water, nitrogen, carbon, and phosphorus cycling changed more rapidly in the second half of the twentieth century than at any time in recorded human history. The human impact on ecosystems has changed not only the structure of the systems, but their processes and functioning as well. World climate has already changed and continues to affect temperature, rainfall, and sea levels. Other important environmental concerns are habitat change, ozone depletion, acid rain, deforestation, water scarcity and pollution (See Table 2.2).

It was stated earlier that people view the natural world around them in different ways. Attitudes towards our natural world seem to vary over time as well. The passion to preserve wild scenery, protect natural habitats and seek the soothing powers of unexploited nature is not a new phenomenon. In some industrialized countries it can be traced back over 400 years, even through regarded by many as a quite recent occurrence (World Energy Council, 2005). The lowest point in Western civilization's attitude towards nature occurred in Europe during middle ages. At that time, nature was commonly viewed with suspicion, fear, and ignorance. However, with the Renaissance (15^{th} century) and Enlightenment (17^{th} and 18^{th} centuries) humans and nature came to friendlier terms (Marsh, 2005).

In the 18^{th} and 19^{th} centuries, the concept of nature was extended to include pleasure and the enjoyment of natural elements. With the Romantic Movement, especially in Britain, the landscapes around buildings were made to look "natural" by using curved lines in gardens, field edges and water features. In the 1800s, the conservation movement emerged, tied to both Romantic and scientific thought. This movement initiated the national park system. Another development of the 19^{th} century was the scientific understanding of the environment's role in the improvement of public health. Municipal sanitary sewers planned and developed. Chicago's system, built in 1855, was one of the first in North America. The development of public water supply systems which could deliver safe drinking water to cities was introduced in the 1930s, with the introduction of water purification by filtration and chlorination (Marsh, 2005).

Table 2.2: Causes and effects of today's common environmental problems

Environmental Problems	Definition	Causes	Effects
Pollution and Waste	Waste and pollution are the unwanted by-products of production process. Any addition to air, water, soil, or food that threatens the health, survival, or activities of humans or other living organisms is called pollution.	Excessive use of agrochemicals, the incidence of oil spills, the spread of acid rain, burning gasses	Disruption of life-support systems for humans and other species; damage to wildlife, human health and property; noise, unpleasant smells, tastes and sights
Climate Change/Global Warming	Climate change refers to the variation in Earth's global climate or regional climates over time. Global warming is the gradual increase in global temperatures caused by the emission of gases that trap sun's heat in Earth's atmosphere.	Internal processes, human activities; chemicals such as carbon dioxide, methane, nitrous oxides, chlorofluorocarbons (CFCs)	Disturbance to habitat conditions and ecosystems, increase in global temperatures, extinction of species
Greenhouse Effect	It is warming of the atmosphere by trapping of longwave radiation being radiated to space.	Water vapour, carbon dioxide, methane and nitric oxide	Increase of Carbon dioxide, pollution, climate change
Ozone Depletion	Ozone layer is thinning over the Antarctic.	Human-made chemicals; chlorofluorocarbons (CFCs)	Damage to human health, air quality, biological life and temperature change
Acid Rain	Wet and dry acid deposition is called acid rain. (Acidic rain, fog and snow, gases and particles)	Reaction of sulfur dioxide (SO2), nitrogen oxides (NOx) and water caused by burning oil, gas or coal	Damage to aquatic life, vegetation (forests), built environment
Deforestation	Cutting down, burning, and damaging of forests	Commercial logging , grazing cattle, planting crops	Destruction of species; degradation of local climates; greenhouse effect; desertification
Habitat Change	Habitat loss is a cause of the degradation of wildlife species, both locally and on a global scale.	Droughts, disease, fire, hurricanes, mudslides, slight increases or decreases in seasonal temperature or precipitation	Less habitat available to wildlife, damage to ecosystems
Invasive Species	Non-native species of plants or animals that out-compete native species in a specific habitat.	Increasing global trade and changing land use patterns	Biodiversity loss, economic loss, damage to agriculture and landscape
Water Scarcity	Water scarcity describes an environment in which demands for water for domestic, agriculture, and industry purposes exceed its availability.	Increase in demand of water, decrease in water resources, overuse of water	Unable to meet ever-increasing demands, habitat loss

One of the most striking phenomena of the past two decades has been the rising concern about human activities that cause greenhouse gas emissions becoming more heavily concentrated in the atmosphere. Atmospheric concentrations of carbon

dioxide, of which at least 75% of that part caused by human emissions is due to fossil fuel burning, have increased by over 31% since 1750 (World Energy Council, 2005).

Early in the 20th century the concept of sustainability was applied in forestry and wildlife management. In plant ecology the key concept was of providing successional change in plant communities. Forests could recover through natural processes after regular cutting and burning. Animal and bird populations could also re-establish themselves, after being under threat, provided that their natural habitat was maintained (World Energy Council, 2005). However, by the 1950s, the amount of evidence showing species and natural communities might not recover from excessive destruction of their habitats increased. In some developing countries, agricultural use of natural resources and deforestation, with the loss of natural habitats and species, has attracted considerable attention.

The sustainable development concept was born out of the emerging environmental movement of the 1950s and 1960s. The movement was concerned that human activity was having severe and negative impacts on the planet. In the 1970s, conservation-sensitive land use planning adopted an ecological perspective. Land uses were designated according to their carrying capacities, environmental sensitivity, and sustainability (Marsh, 2005).

The concept of sustainable development received its first major international recognition in 1972 at the UN Conference on the Human Environment held in Stockholm. Sustainability was the focus of the World Conservation Strategy, published by the World Conservation Union (IUCN) in 1980. In 1987, the term 'sustainability' term was popularized in 'Our Common Future', the report of the World Commission on Environment and Development, often referred to as the Brundtland Report (Sustainable Development Commission, 2005). It included environmental concerns such as population pressures and human resources; food security; species and ecosystem protection; energy supply alternatives; industrial production and efficiency; urban, institutional and legal challenges.

The concept of sustainable development has received most attention since the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. The summit marked the first international attempt to draw up action plans and

strategies for moving towards a more sustainable pattern of d evelopment. Over 100 Heads of State with representation from 178 national governments attended it. The Summit involved representatives from a range of other organizations representing civil society (World Energy Council, 2005).

The Kyoto Protocol negotiated in 1997 is an amendment to the United Nations Framework Convention on Climate Change (UNFCCC). Countries that ratify this protocol commit to reduce their emissions of carbon dioxide and five other greenhouse gases, or engage in emissions trading if they maintain or increase emissions of these gases. Some 141 countries, accounting for 55% of greenhouse gas emissions, have ratified the treaty, which pledges to cut these emissions by 5.2% by 2012 (BBC News, 2004). In 2005, Kyoto Protocol has come into effect. Most countries have pledged to reduce the emission of gasses that contribute to global warming.

In 2002, the World Summit on Sustainable Development held in Johannesburg was attended by 191 national governments, UN agencies, financial institutions and other major groups to assess progress since Rio. The Johannesburg Summit delivered three key outcomes: a political declaration, the Johannesburg Plan of Implementation, and a range of partnership initiatives. Key commitments included those on sustainable consumption and production, water and sanitation, and energy (Sustainable Development Commission, 2005). After 2002, G8 Summits, took place every year in a different location, committing G8 members to reduce, recycle and reuse of their products and materials. These summits tackled with issues about sustainable development, environmentally managed oceans and seas and global climate change.

The European Union (EU) leaders agreed in 2001 to halt the loss of biodiversity in the EU by 2010 and to restore habitats and natural systems. The timescale for delivering on this commitment has now reached the halfway mark. Currently, the Green Week 2006 conference programme looks at key aspects of EU biodiversity policy and potential approaches for strengthening cooperation with stakeholders to ensure the 2010 target is reached.

Nowadays, sustainability has become a main topic at engineering, planning and architecture conferences and summits. According to International Institute for

Sustainable Development (IISD) (2005) the most important events in the sustainable development timeline from 1962 to 2006 are given in Table 2.3.

Table 2.3: World summits and conferences about sustainability and environmental issues (International Institute for Sustainable Development-IISD, 2005)

Year	Summit, Conference, Research, Act
1962	Silent Spring by Rachel Carson brought together research on toxicology, ecology and epidemiology to suggest that agricultural pesticides were building to catastrophic levels.
1969	National Environmental Policy Act is passed in the U.S., creating the Council on Environmental Quality and establishing a national policy for the environment.
1970	First Earth Day held as a national teach in on the environment. An estimated 20 million people participated in peaceful demonstrations across the U.S.
1972	UN Conference on Human Environment/UNEP held in Stockholm is rooted in the regional pollution and acid rain problems of northern Europe.
1973	U.S. enacts Endangered Species Act to better safeguard, for the benefit of all citizens, the nation's heritage in fish, wildlife and plants.
1976	Habitat Summit is the First global meeting to link environment and human settlement.
1985	Climate change. Austria meeting of World Meteorological Society, UNEP and the International Council of Scientific Unions reports on the build-up of CO2 and other "greenhouse gases" in the atmosphere. They predicted global warming.
1987	Our Common Future Brundtland Report
1992	Earth Summit. UN Conference on Environment and Development (UNCED) held in Rio de Janeiro.
1997	Kyoto Protocol. This document sets goals for greenhouse gas emission reduction and establishes emissions trading in developed countries and the clean development mechanism for developing countries.
1999	The World Commission on Forests and Sustainable Development releases its report "Our Forests...Our Future". This independent Commission, after extensive hearings with stakeholders worldwide, concluded that the world's material needs from forests can be satisfied without jeopardizing them by changing the way we value and manage forests.
1999	Launch of the first global sustainability index tracking leading corporate sustainability practices worldwide. Called the Dow Jones Sustainability Group Indexes.
2000	The Second World Water Forum and Ministerial held in The Netherlands.
2001	The Marrakech Accords, agreed to at COP-7, finalize how the Kyoto Protocol should work, lay the groundwork for ratification by different countries and mark the conclusion of a process begun at COP-4 in Buenos Aires.
2002	World Summit on Sustainable Development held in Johannesburg, South Africa.
2003	G8 Summit in Evian, France. Marine Environment and Tanker Safety.
2004	G8 Summit took place in Sea Island, Georgia.
2005	G8 Summit took place at Gleneagles Hotel, Scotland. The main agreements reached covered development in Africa and tackling global climate change. Kyoto Protocol comes into effect. Most countries are now pledged to reduce the emission of gasses that contribute to global warming.

2.4.2 Sustainability in Campuses

Environmental concerns have impacted on all aspects of design. In general, all dimensions of life have to pay attention to global warnings to facilitate ecosystem services and better manage scarce environmental resources. University campuses, as places of science and innovation as well as community grounds, can lead communities by training younger generations via educational programmes and also by being better examples of the implementation of green design principles.

Higher education institutions make a significant contribution to sustainable development and environmental awareness in their roles as providers of teaching and research, and in the way they engage positively with their local and global community (HEPS, 2003). Universities that have come up with a statement of principles towards becoming "a sustainable university" share, first of all, a commitment to act in an environmentally friendly way and show leadership to other universities and the community (Vardy, 2001).

A Green Campus is one that carries out functions in an effort to achieve sustainability. It tries to balance function and design with existing and foreseen resources. It consists of buildings and landscapes where environmentally responsible practice and education take place together. At its best, it can provide a model where operational functions, business practices, academic programmes, and people are interlinked, providing educational and practical value to the institution, the region, and the world (PETE and EPA, 2005).

Some universities have made declarations on environmental protection, sustainable development and green design. The Table 2.4 shows the list of the declarations made by Universities around the world according to the International Institute for Sustainable Development (Johnston, 2005).

Table 2.4: The declarations made by some universities

Declaration	Date	Location
Talloires Declaration	1990	France
Halifax Declaration	1991	Halifax,Canada
Earth Summit Agreements	1992	Rio de Janeiro
ACU -- Swansea Declaration	1993	Swansea, Wales
Kyoto Declaration	1993	Japan
CRE Copernicus Charter	1993	Barcelona,
Student Declaration for a Sustainable Future	1995	UK

Since 1990, over 300 institutions in 40 countries have signed the Talloires Declaration, pledging to "provide the leadership and support to mobilize internal and external resources so that their institutions respond to this urgent challenge." In 1993, at the Universities Fifteenth Quinquennial Conference in Swansea, Wales, participants drawn from over 400 universities in 47 different countries focused on the topic of people and the environment. Then in the same year, the International Association of Universities (IAU) issued a clarion call to its 650 university members in the Kyoto Declaration. The University Charter for Sustainable Development, signed by 213 universities in Europe, expresses a collective commitment on behalf of a large number of universities. It represents an effort to mobilize the resources of institutions of higher education to further the concept and objective of sustainable development (Johnston, 2005).

The Campus Earth Summit brought together 450 faculty, staff, and student delegates from 22 countries, six continents, and all 50 states from US at Yale University in 1994 in order to craft the blueprint for a green campus, which is a set of recommendations for higher education institutions to work toward an environmentally sustainable future (Simpson, 2001). In 1995, the Community Environmental Educational Development (CEED) organization, a student run body, held a conference to produce a national environmental declaration for students (Johnston, 2005).

The National Wildlife Federation (NWF) Campus Ecology Programme is also a significant programme that assists students and administrators in transforming universities into learning and teaching models of environmental sustainability since 1989. This programme supports and promotes positive and practical conservation projects on campus and beyond to protect wildlife by restoring habitat and slowing

global warming. Best practices of green design in some campuses can be found on the NWF website.

As a result of these summits, conferences, programmes and declarations various sustainability assessment frameworks have been developed for university campuses (See Table 2.5).

Table 2.5: Sustainability Assessments developed for University Campuses

Assessment	Description	University Examples
Blueprint for a Green Campus	It is developed at a Campus Summit at Yale University in 1994. It gives recommendations for greening campus operations, curricula, and community relations.	University of Colorado at Boulder, The State University of New York at Buffalo, UC Santa Cruz
National Wildlife Federation (NWF) Campus Ecology Program	It offers practical recommendations about starting projects and details best management practices.	Numerous examples of best practices are available on NWF website.
Clean Air Cool Planet	It is based on Kyoto Protocol. It advocates greenhouse gas emission calculations as well as adopting the provision of the protocol.	Tufts University, Massachusetts Institute of Technology
Ecological Footprint	It measures the amount of renewable and non-renewable ecologically productive land area required to support the resource demands and absorb the wastes of a population.	University of Newcastle (Australia), University of Redlands, Oxford Brookes University (UK),
ISO 14001	International Organization for Standardization (ISO) was adapted for campuses as ISO 14001 by US Environmental Protection Agency (USEPA).	Tulane Humboldt State, University of Missouri, Leeds Metropolitan University
The Natural Step	It is founded in Sweden. It is a conceptual framework for addressing environmental problems.	Georgia Institute of Technology, University of Texas at Houston
Tallois Decleration	Twenty universities from all regions of the world publicized their concerns about environmental problems in 1990.	10 campus based actions to reduce environmental degradation.
ULSF Sustainability Assessment Questionnaire	It aims to raise consciousness and encourage debate about what sustainability means for higher education practically and philosophically.	Best practices are available on ULSF website.
Campus Sustainability Assessment Framework (CSAF)	This framework was developed to create a consistent way of measuring socio-economic and ecological sustainability on campuses in 2003. It is the most common sustainability assessment framework used in campuses across the world.	Greening the Ivory Towers Project, Concordia University , University of California Berkeley

This table is adapted from Savanick (2004, pp.19-20) and Second Nature (2005).

Internationally, sustainability is considered an essential component to the future well being of humanity and the planet. Various universities have already become engaged in the process of integrating sustainable development in their activities. As many different definitions and interpretations of the concept exist, it is not surprising that different strategies are emerging in those universities that are beginning to strive for sustainability (Weenen, 2000).

Many universities in the United States, Canada, United Kingdom and elsewhere have started the greening process and are now actively implementing green design in their campuses. The Table 2.6 shows the green design initiatives at some universities across the world.

Table 2.6: Green design initiatives at some universities

University	**Green Design Initiatives**
University of California Berkeley (US)	Campus Sustainability Assessment
University of British Columbia (Canada)	Sustainable Development Policy
Cornell University (US, New York)	Cornell Sustainable Campus Project
Carnegie Mellon (US, Pennsylvania)	Carnegie Mellon Green Practices
Harvard University (US)	Harvard Green Campus Initiative-projects on green buildings, water, energy conservation, efficiency, and renewable energy
Oberlin College (US)	Environmental Policy Statement
Brown University (US, Rhode Island)	Brown Is Green (BIG)-Campus Environmental Stewardship and Resource Conservation Programme
Penn State University (US)	Centre for Sustainability and Green Destiny Council
Tufts University (US, Massachusetts)	Tufts Climate Initiative - Tailores declaration
Mount Holyoke College (US)	Projects on green buildings, greening the curriculum, hybrid vehicles, conservation, recycling, etc.
Concordia University (Canada)	Campus Sustainability Assessment Framework (CSAF)
University of Michigan (US)	"Sustainable University of Michigan" initiative, Environmental Stewardship
McGill University (Canada)	Greening McGill- Rethink your environment
University of Nottingham (UK)	Jubilee Campus- Environmental and ecological strategies
University of Bradford (UK)	Ecoversity Project
University of Birmingham (UK)	Carbon Management with the Carbon Trust, University Paper Recycling Scheme, Eco-Centre Award for Priestly Centre

Table 2.6 continues.

University	Green Design Initiatives
University of Hertfordshire (UK)	Environment Team- Projects on recycling, energy conservation, sustainable purchasing, biodiversity, etc.
State University of New York at Buffalo (US)	SUNY-Buffalo UB Green
University of Waterloo (Canada)	WatGreen - Greening the Campus
University of Oregon (US)	Campus Recycling Programme, Comprehensive Environmental Policy Statement
University of Minnesota - Twin Cities Campus (US)	Sustainable Campus Initiative -Sustainability and U- green lights, alternative fuel-oat hulls, wind energy projects, etc.
Michigan Technological University (US)	Green Print for Environmental Sustainability in Campus Operations and Activities
The University of York (UK)	Policy on Sustainable Development
University of Maryland (US)	Campus Ecology Project
Yale University (US)	Yale University Office of Sustainability- construction of a new green facility
Rice University (US)	Student project-Assessment of Rice University as an Environmental System
University of Colorado (US)	Blueprint for a Green Campus
University of New Mexico (New Mexico)	Taos Sustainability Initiatives- Taos Green Guide- Projects on green building, solar water heating, renewable-wind energy use, etc.

CHAPTER 3. GREEN DESIGN IN CAMPUS LANDSCAPE

> *"Every school, college, and university has a formal curriculum described in its catalogue. But it also has a hidden curriculum consisting of its buildings, grounds, and operations. Like the infrastructure of the larger society, it structures what students see, how they move, what they eat, their sense of time and space, how they relate to each other, how they experience particular places - and it affects their capacity to imagine better alternatives"(*Orr, 1999).

Campus landscapes can be set out to educate through their design and routine operations by implementing green design. The campus landscape can be designed to teach ecological competence in horticulture, natural systems agriculture, ecological restoration, forestry, aquaculture, water and energy conservation, and techniques to preserve biological diversity. Campus landscapes also give students and its users the opportunity of direct experience that connects them to soils, plants, water, forests and wildlife (Orr, 1999).

Campus landscapes can be valued as a component of a larger energy system. They can conserve energy by orienting buildings, building green roofs and windbreaks in order to block winter winds and provide heat in winter or shading and cooling in summer. A sustainable campus landscape can minimise the use of water, fertilizers, pesticides, labour, and building materials. Green design in campus landscape means working toward a thoughtful balance between resources used both in construction and maintenance of the campus.

University of New Mexico, Gallup, and Standford University can be given as environmentally friendly and ecologically sensitive campus examples. Repeated drought cycles and erosion of sandstone architecture, caused by irrigation water, have lead Stanford University back to Olmstead's methods which were naturalistic. For ornamental landscapes, native and adapted species are chosen over energy and water intensive exotics. Rather than spending millions on an underground storm water system, the university constructed a wetland to act as a buffer from heavy rain runoff and as a buffer area which can recharge groundwater supplies (Dober, 1992).

The Adam Joseph Lewis Center for Environmental Studies at Oberlin College in U.S provides a "living classroom" for university students (Figure 3.1). Passive solar heating and lighting were optimized. A 3,700 square-foot solar electric system on the main south-facing curved roof provides electrical energy for the building. Recycled and reused products were used in the construction of the complex. An energy management system monitors the building's energy use and key environmental variables throughout the building and landscape. A wetland provides a natural waste-water treatment system that uses microbes, plants, snails, and insects, and is designed to treat the building's wastewater daily (High Buildings Performance Research, 2006).

Figure 3.1: Adam Joseph Lewis Center for Environmental Studies at Oberlin College (Green Buildings BC Resources Guide, 2006)

At Pennsylvania State University Park, the Center for Sustainability has an 8.5-acre Research and Demonstration Site for Ecological Technologies. The Center offers courses, workshops, and conferences. The site highlights green design principles and building techniques, alternative energy and alternative materials, sustainable agriculture, and ecosystem restoration. The major projects include Living Machine for applied research and education, a passive solar roof, a passive solar greenhouse (bioshelter), bio-intensive mini farming and composting facilities (Second Nature, 2005).

Conserving water, providing compost and fuel, using renewable energy sources, recycling wastewater, providing wildlife, improving air quality, and using

sustainable materials are some of the green design practices that can be employed in campus landscapes to achieve the sustainability goals of universities.

In this study green design in campus landscapes have been assessed under several implementation areas for which criteria term will be used in the following chapters by illustrating best practices across the world. This chapter evaluates physical and ecological dimensions of green design for sustainable development while the next chapter examines the social dimensions. In this chapter, the physical criteria related to green design have been determined and defined comprehensively. For each criterion, various universities in the world have been given as examples. These criteria are energy conservation, waste management, water management, pest management, sustainable landscape materials, wildlife habitat conservation, and landscape maintenance, transportation and car parking.

3.1 Energy Conservation

Energy consumption produces the most significant environmental impact associated with campus operations. There is a need to operate campus in an energy-efficient manner and to employ conservation measures wherever possible. The energy source used by campus operations and the equipment chosen for campus buildings and landscapes are very important from sustainability stand point (Simpson, 2003).

Energy conservation can be attained by landscape design practices. Landscaping has an important role in changing the microclimate of a place. By manipulation of natural elements or processes, some of the harsh effects of sun and wind can be minimised and in this way energy can be conserved or provided from them. Every area has different climatic and natural properties. Consequently, size, soil type, sun and wind exposure are factors which determine appropriate landscaping for energy conservation.

Each of the major climatic regions has different needs for energy conservation by landscaping. For instance, in cooler regions it is necessary to utilize as much heat as possible in order to decrease energy consumption. In hot climates it is desirable to provide cooling. In arid areas existing moisture has to be maximised in order to make the climate more habitable (Vig, 2003).

The goal of energy conservation by landscaping is to regulate energy flows coming from the sun and the wind. A few common design elements that directly or indirectly affect thermal conditions and thereby the energy consumption in a site are landscaping, the ratio of built form to open spaces, location of water bodies, building orientation and plan form (Vig, 2003).

In this part, the techniques for energy conservation through the use of topography, land use, building orientation, vegetation, green roofs, water, energy-efficient landscape lightening and renewable energy types will be discussed.

3.1.1 Topography-Land Use and Building Orientation

Topography natural or man-made has the ability to modify climatic variations in different ways. According to the article "Landscape Techniques for Energy Conservation", large landforms such as mountains are diverters of air masses, affecting the flow of moisture-laden air and causing rain shadows (Vig, 2003). It is also emphasized that airflow patterns may change in the areas with large variation of landforms. Even smaller landforms may be involved in either solar radiation interception or in wind control through interception and deflection. Vig recommends the creation of small landforms in larger ones to provide better orientation or site conditions for the utilization of solar radiation.

In hilly areas where sun is necessary but wind needs to be cut landforms can block unwanted wind or other influences and also provide an area in which the solar radiation for a specific area is maximized. Vig (2003) believes that it may be advisable to locate solar collection devices away from the building utilizing the solar energy gathered by the collectors. In such cases landforms may be created or utilized to integrate the solar collection device with the surrounding landscape. At times the necessary engineering or architectural devices used for solar collection on a building may be unsightly and it may become necessary to screen it by smaller landforms. Landforms, especially smaller ones, can, if properly controlled and manipulated, direct wind patterns either towards or away from specific areas. Location of water bodies can also affect the thermal conditions in the site. The ratio of built environment to open spaces can affect the microclimate of the site.

Where buildings are situated on a site and how they are oriented provide significant opportunities to reduce overall environmental impacts (Wilson, 2001). Building orientation designed through green design approach maximizes opportunities for passive solar heating, solar heat gain avoidance during cooling times, natural ventilation as needed, and daylighting throughout the year.

Building orientation can be considered in the design process of the campuses in order to take advantage of the sun and wind. In the winter the object is to maximize the amount of sun enters into the building to maximize the heat gain and natural lighting. In the summer it is important to block the sun, so as not to overheat the building. However, in the summer the wind can be used to cool the building with natural ventilation, while in the winter it will cause substantial heat loss. During the design process it is important to find a way to block the wind in the winter and use it in the summer (Landry, 2005). Building construction can be implemented to take advantage of natural landforms by earth sheltering and positioning in the building orientation applications. In this manner, energy use for lighting in all buildings can be minimised by letting the natural light in by orientation and the internal layout of the building.

Cleveland State University (U.S) Campus Master Plan states that campus buildings will be sited to maximize their visual appeal and reduce energy demands. In addition, living areas will be oriented to receive direct sunlight and canopies, overhangs, or trellis are encouraged to allow low winter sun into these areas, while blocking the high summer sun (Cleveland State University Campus Master Plan, 2005).

3.1.2 Vegetation

Various climatic impacts can be controlled by rational organization and plantation of trees, shrubs, and vines. Moreover, vegetation can clear the air, and conserve energy while creating aesthetically more attractive environments. Trees, espaliers and vines, and groundcovers are the types of plants which will be assessed in this part to enlighten energy conservation and to minimise wind and dust effects.

Trees reduce unwanted summer temperatures significantly. Deciduous trees provide summer shade, then drop their leaves in the fall and allow sunrays to filter through bare branches in winter and help buildings to warm up (Figure 3.2). The larger the tree, the more shade and windbreak has associated energy savings. However, it is important to choose species that fit the space available (Powell, 1996).

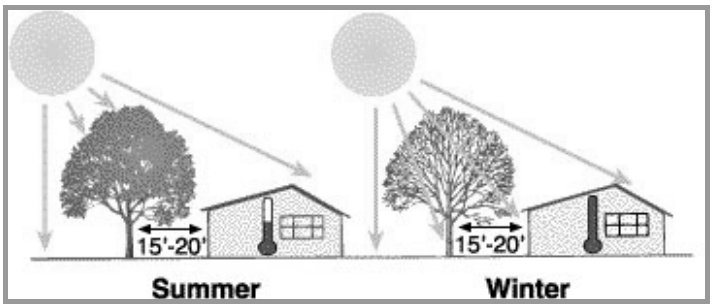

Figure 3.2: Shading by deciduous trees in summer and winter (Welch, 1988)

Espaliers help to insulate exterior walls from summer's heat and winter's cold. However, they should only be trained up undamaged walls, away from wooden sills, shutters and doors to prevent moisture damage. Vines, shrubs and certain trees can be used as espaliers. Screening outdoor air conditioning equipment with plantings can reduce energy consumption as well. However, special attention is needed for shrubs planted near the compressor not to obstruct the air flow or access (Welch, 1988).

Summer temperatures can be reduced by using turf and groundcover plants between buildings and paved areas such as driveways and sidewalks. The temperature on groundcover is mostly 10 to 15 degrees cooler than above a heat absorbent material such as asphalt or a reflective material such as light coloured gravel or rock. In hot climates it is best either to minimize the use of heat absorbent and reflective materials or to shade them from any direct sun. Groundcover plants and turf also have the cooling effect due to evapotranspiration (Powell, 1996).

Windbreaks and shelterbelts can control wind. The term shelterbelt refers to extensive barriers of trees protecting fields. More precisely, a shelterbelt is considered to be a dense type of windbreak. A windbreak may be only a single row of vegetation (typically trees or shrubs) to reduce the force of the wind or to direct

snow. In a windy site, a windbreak or shelterbelt planting can account for up to 50 % wind reduction with a 20 % to 40 % reduction in heating fuel consumption. In a calmer spot, wind barriers can still reduce fuel use by 10 % or more. A wind barrier that permits 50 % to 60 % wind penetration is more effective than a solid barrier, because it provides a larger area of protection on the leeward side (Tech, 2001) Evergreen conifers (needle-leaf trees) are a perfect barrier to winter winds (Figure 3.3).

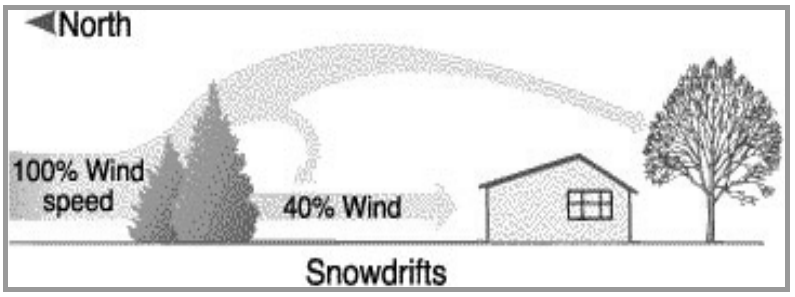

Figure 3.3: Wind curtailment by vegetation (Welch, 1988)

Windbreaks obstruct and redirect the flow of wind. They can also reduce the wind velocity. Windbreaks composed of living plants allow some of the wind to penetrate which makes them more effective. The effective zone of protection for a living windbreak is approximately thirty times its height, although maximum protection occurs in a range of 5 to 7 times of the height of the planting (Welch, 2006).

3.1.3 Green Roofs

Green roofs, also known as vegetated roof covers, eco-roofs or nature roofs are multi-beneficial structural components that minimize the energy loss by insulating the buildings in winter and reducing air conditioning need in summer. Additionally, green roofs help to mitigate the effects of urbanization on water quality by filtering, absorbing or detaining rainfall. They are constructed of a lightweight soil media, underlain by a drainage layer and a high quality impermeable membrane that protects the building structure. The soil is planted with a specialized mix of plants that can thrive in the dry, high temperature conditions of the roof and tolerate short periods of overflow from storm events (Velazquez, 2006).

The benefits of green roofs are as follows;

- Minimising CO_2 impact
- Reducing summer air conditioning cost
- Reducing winter heat demand by insulating the roof
- Reducing heat island effect in urban areas
- Reducing and controlling rainwater run-off
- Protecting biodiversity
- Improving wildlife
- Softening the buildings' harsh effect by planting
- Aesthetically pleasing
- Educating people by being a demonstration garden

A project regarding construction of green roofs on the roof of some academic buildings of Carnie Melon University campus was initiated by the group, Sustainable Students of the university. The roof of Hamerschlag Hall is one of the completed green roofs of the university and can be seen in the Figure 3.4 (Carnegie Mellon University, 2005).

Figure 3.4: Carnegie Mellon University, Hamerschlag Hall (Carnegie Mellon University, 2005)

Green roofs designed with turf can provide high profile insulation by sustaining a constant temperature throughout the year. During the winter they keep the heat in, and in the summer they provide a relatively cool environment (Figure 3.5).

Figure 3.5: An example of green roof with turf (Safeguard Europe, 2005)

3.1.4 Water

Water has profound impact on climate control, especially in the utilization of solar radiation and energy conservation. Water stores a large percentage of insulation striking a water surface while a small percentage is radiated off. At the same time, when a small percentage of the solar energy strikes the land surface a large percentage of the same energy is radiated back into the atmosphere. Breeze flows from the water body onto the shore during the day and vice versa at night. This natural airflow pattern may be utilized and controlled for natural ventilation and energy conservation (Vig, 2003).

The Jubilee Campus of The Nottingham University has some sustainable design features which include a series of lakes which provide cooling for the buildings in the summer time (Figure 3.6).

Figure 3.6: The artificial lake in the Jubilee Campus (Geograph, 2006)

3.1.5 Energy-Efficient Landscape Lighting

Solar powered lighting features, low voltage lights and motion detectors help to conserve energy at campus outdoors. The specially designed solar panels or cells in solar powered lights collect natural sunlight and convert it into electrical power that is stored in highly efficient rechargeable batteries. They have built-in photo sensors so they automatically turn off during the day and turn on at night. Light from solar powered lamps does not require the burning of fossil fuels and the generation of carbon dioxide (CO_2) and pollutants associated with the generation of electricity by a utility. At Cornell University there is a program called “The Solar-Powered Lighting System” which aims to provide a cost-efficient, environmentally friendly alternative to traditional passenger shelter lighting options. In 1996 Solar powered lights were installed in the passenger shelters of the University campus (Cornell University, 2005).

Students of The Warren Wilson College installed several small solar-powered lights in response to a need for additional lighting on campus. The solar lights are low to the ground, and illuminate the walkway without obscuring the view of the night sky. This is a good energy conservation and environmentally friendly design practice

supporting Warren Wilson College's Campus Greening Seed Grant Program (Warren Wilson College, 2006).

Reducing wattage and using motion detectors can also help to conserve energy by using energy efficiency outdoors as well as indoors. Outdoor lighting systems have several smaller transformers are usually designed for safety of movement, security, and decoration. Safety of movement on stairs, walkways and paths are essential. Therefore, motion detectors can be used to help conserve energy while providing safe illumination. Energy-efficient landscape lighting systems can provide more attractive outdoors as well as safer and more secure environments (The Urban Farmer Store Bulletin, 2001).

3.1.6 Renewable Energy

Renewable energy is derived from inexhaustible sources such as wind, the sun, sea, or replaceable sources such as waste products and crops. In this part commonly used renewable energy types will be explained as follows:

- Solar energy
- Wind energy
- Biomass energy
- Hydropower and Hydroelectric Energy
- Geothermal energy

The principle for solar energy is to optimise the amount of energy that can be derived from the sun. This can be achieved through the careful design and orientation of a building or whole development. There are three main ways of using solar energy; passive solar energy, solar water heating and photovoltaic energy.

Passive solar techniques make use of solar energy by means of building designs that carefully balance their energy requirements with the building's site and window orientation. Building elements such as walls, windows, floors and roofs, in addition to exterior building elements and landscaping can be used for passive solar design. Solar heating, cooling and natural lighting can be achieved by passive solar design.

Solar heating designs collect and store thermal energy from direct sunlight. Heat gain can be controlled by good insulation, reduced window size and by the use of reflective materials in the walls and roof (Solar Energy Society of Canada Inc., 2006). Green roofs provide thermal insulation. The soil layer on the roofs slows heat transfer to the structure in the summer and reduces heat loss in the winter. Passive cooling minimizes the effects of solar radiation through shading or generating air flows with ventilation.

Solar water heating requires the installation of a water collector, usually in the roof. Water is pumped through a collector, absorbing heat from solar radiation. Solar panels can be incorporated into the structure of the roof to supplement water heated by conventional systems (The State of Queensland Department of Education, 2000). Photovoltaic (PV) cells which are used to construct solar panels convert solar radiation into electricity. These can be incorporated into roofing materials, cladding and enabling electricity to be generated from the sun.

The University of Brighton installed glass-tube solar panels on the roof of Hillbrow Sports Complex, at its Eastbourne campus (Figure 3.7). It is the largest solar thermal installation in a higher education institution in Europe. Currently, the panels provide energy to heat the water in the 25m swimming pool. The project aims to reduce carbon emissions and provide an education resource to the University students and the community (University of Brighton, News archive, 2005).

Figure 3.7: The glass-tube solar panels on the roof of Hillbrow Sports Complex at the University of Brighton (University of Brighton, 2005)

Small wind turbines may be able to be incorporated into some developments to take advantage of wind energy. The power generated by these will generally be insufficient to power the whole development but can be combined with another source. Wind turbines should be sited so as to limit the visual impact on the amenity of adjoining buildings and in certain locations such as conservation areas they are not encouraged (The State of Queensland Department of Education, 2000). Carleton College's (Minnesota) wind turbine (Figure 3.8) was constructed in August 2004 in an area owned by the College after long site researches, meetings with the local community and assessments started in 2002 (Carleton College, 2001).

Nowadays, purchasing wind energy or other renewable energies for campus energy requirements and on-site wind turbine and wind farm projects are popular in the US and the UK. Most universities purchase wind energy to meet their energy need. Some find sites to build wind farms while others use the opportunity by creating small wind turbines in their campuses. In 2001, the University of Pennsylvania, Penn State University, and Carnegie Mellon University made the three largest retail wind energy purchases in US.

Figure 3.8: Carleton College Wind Turbine (Carleton College Buildings and Grounds Committee and Board, 2001)

Biomass is plant matter such as trees, grasses, agricultural crops or other biological material. It can be used as a solid fuel, or converted into liquid or gaseous forms, for the production of electric power, heat, chemicals, or fuels. Landscape materials and waste can be used as a source of biomass energy. Today, environmental and economic concerns have created many new opportunities for the use of biomass energy. Biomass can play an important role in reducing greenhouse gas emissions and air pollution.

Burning biomass is not the only way to release its energy. Biomass can be converted to other usable forms of energy like methane gas or transportation fuels like ethanol and biodiesel. Agricultural and human waste release methane gas (also called "landfill gas" or "biogas"). Crops like corn and sugar cane can be fermented to produce the transportation fuel, ethanol. Biodiesel, another transportation fuel, can be produced from left-over food products like vegetable oils and animal fats (National Renewable Energy Laboratory, 2006).

The Biomass Fuel Project at University of Iowa in USA has aimed to reduce fuel costs, reduce greenhouse gas emissions, and utilize a renewable waste product as a resource by using biomass. The University of Iowa Power Plant supplies 100% of the campus heating and 30% of the campus electrical demand. The Power plant uses oat hulls and coal to produce energy (Langenberg, 2003).

Hydropower is the energy from water sources such as oceans, rivers and waterfalls. Electricity is produced by directing or channelling moving water to power electric generators. Although hydroelectric power doesn't cause pollution, there are many other environmental impacts to be considered. Ecosystems may be destroyed, cultural sites may be flooded and sometimes people need to be resettled. There are also impacts on fish breeding, loss of wildlife habitat and changes in water flow-regimes of rivers (Table 3.1). Because of the environmental impact of traditional hydroelectric projects schemes, there has been increasing interest in alternative hydro schemes. Pumped storage systems can be installed on existing dams. Run-of-river hydroelectric schemes cause less environmental damage. Large dams do not need to be built, as the run-of-river schemes divert only part of the river through a turbine (The State of Queensland Department of Education, 2000).

Geothermal energy uses heat energy from beneath the surface of the earth. Some of this heat finds its way to the surface in the form of hot springs or geysers. Other schemes tap the heat energy by pumping water through hot dry rocks several kilometres beneath the earth's surface. Geothermal energy is used for the generation of electricity and for space and water heating in a small number of countries (The State of Queensland Department of Education, 2000). Geothermal energy can be unsafe because of the hazardous gases and minerals that may come up from underground during the disposal process.

Table 3.1: Advantages and disadvantages of renewable energy types

Renewable Energy Types	**Use of Renewable Energies**	
	Advantages	**Disadvantages**
Solar Energy	Non-polluting	High construction costs
	Generates electricity for heating	Large area requirements to get decent amount of power
	Provides cooling and natural lighting	Short lifetime
	Safe	
Wind Energy	Non-polluting	Aesthetically not desirable
	Freely available in many areas	Generates noise in rural areas
	Provides cheap electricity	Not suitable for conservation areas
	Safe	
Biomass Energy	Generates electricity	Fuels produce greenhouse gases
	Biodiesel-fuel for transportation	Expensive source
	Uses waste materials	Loss of wildlife
	Safe	
Hydropower Energy	Generates electricity	Damage to cultural sites
	New systems such as run-of-river hydroelectric schemes cause less environmental damage	May cause relocation of people
	Safe	Cause poor water quality
Geothermal Energy	Non-polluting	Not available in many locations
	Generates electricity	Unsafe to dispose because of hazardous gases and minerals that may come up from underground
	Provides heating	

As one can see from the table above, all renewable energy sources have both advantages and disadvantages. Choosing renewable energy type suitable to site conditions and university policies is important to benefit from these sources efficiently.

3.2 Waste Management

Waste management comprises collection, transport, processing or disposal of waste materials in order to reduce their effects on the environment and human health. In recent years, new policies and strategies have emerged for more sustainable processes to reduce waste materials' effect on the environment and to reuse wasted resources. A Ministerial Statement made in 2005 on waste planning provides an integrated framework in UK to meet EU obligations and national policy (DEFRA, 2006).

As from August 2005, a generic agreement came into force at the University of Portsmouth in partnership with other Southern universities in UK to provide a reduction of general waste. All waste receptacles were "chipped and pinned" to form accurate information of high producers of waste material and take actions to reduce the levels of waste collection. Cardboard, paper, glass, metal, toner cartridges, electronics are designated as recycling materials within the University campus (University of Portsmouth, 2006).

Recycling and waste reduction activities are the most popular campus greening programs. These projects involve recycling of materials, ranging from cans, glass, cardboard and paper to food and yard trimmings, construction materials and laboratory chemicals. Most of the American Universities have waste management and recycling programs to support sustainable campus image in their campuses as in the UK cases.

3.2.1 Waste Reduction and Recycling

Waste reduction, in order to benefit the environmental quality, may also reduce raw material costs as well as waste disposal expenditure. Waste materials such as leaves, trees, shrubs, brush, lumber, asphalt, concrete, water, pesticides, fuel and oil used for landscaping can be recycled and their effects on the environment can be reduced with methods listed below (EPA, 2005).

There are four basic approaches for waste management that can be applied to campus greening efforts. These are;

- Reducing
- Reusing
- Recycling
- Purchasing

Reducing the production of waste is the first and the most important step towards efficient resource use. Designing a new landscape or updating a current one can mitigate to avoid new product use simply by the replacement or regular maintenance of existing ones. This approach will result in a decrease in the future waste amount effectively. By delaying the final disposal of materials and encouraging reuse, full utilization throughout the life time of the product can be achieved. Many items can be reused effectively without much effort, time and energy. Recycling is also another efficient tool of waste management. Recycling can reduce waste generation by recovering and reprocessing usable products that might otherwise to be disposed of. Finally, purchasing sustainable materials can be an effective tool to waste management. Looking for products that have a better environmental impact profile can help environmental quality by decreasing environmental impact costs. Additionally, recycled products are often more durable than those made with raw materials (EPA, 2005).

The University of California Santa Cruz Recycling Program has been collecting materials from across the campus since 1989. The goal of the Recycling Program is to divert materials from the waste stream. It collects clear and coloured glass; aluminium, tin, and steel cans; paper, and plastic materials. Members of the University community can easily recycle their materials in the recycling bins that are located all around the colleges, classroom buildings, offices, cafes, dormitories and other parts of the campus (University of California Santa Cruz, 2006).

3.2.2 Composting

Composting is a specialized part of recycling in which organic wastes are biologically decomposed into a product that can be applied to the land beneficially without environmental damage. Compost is a rich, dark, crumbly material (Tammemagi, 1999).

Compost products improve the quality of landscape materials by improving soil and plant fertility, conserving water, lessening landfill impacts, reducing erosion, regulating runoff, and decreasing the dependency on fertilizers and pesticides. In addition, diverting organic materials from landfills can reduce their environmental impact, including green house gas emissions. According to Earth 911 (2006), benefits of using compost are classified as below;

- Improves the soil structure and density and creates a better plant root environment
- Reduces erosion and runoff
- Increases moisture infiltration and permeability of heavy soils
- Improves water-holding capacity, thus reducing water loss and leaching in sandy soils
- Supplies a variety of macro and micronutrients
- Supplies significant quantities of organic matter
- Supplies beneficial micro-organisms to soils and growing media
- Improves and stabilizes soil pH

“Compost provides superior filtration and erosion control, is more easily installed and maintained, and does not require energy-intensive removal or disposal from the site after the job is completed” (Schwab, 2004, p. 22).

According to Pennsylvania Department of Environmental Protection (2006) compostable materials are listed as below;

- Most landscaping wastes such as leaves, grass clippings, plant stalks, vines, weeds, straw, hay, twigs and branches

- Food wastes including fruit and vegetable scraps, coffee grounds, eggshells and nutshells
- Hair clippings, feathers, straw, livestock manure
- Wood ashes, sawdust, plants treated with herbicides or pesticides (these materials should be composted only in limited amounts)

Materials should not be composted if they promote disease, cause odours, attract pests, or create other nuisances. These include meat, fish, poultry, dairy products, foods containing animal fats, weeds with developed seed heads, and plants infected with or highly susceptible to disease, such as roses and peonies.

The University of British Colombia (UBC) in Canada produces about 1900 tonnes of compostable waste each year including food waste, residual paper products, animal bedding, animal waste, wood, yard waste and sawdust. In June 2000, the UBC's Compost Project was created for waste reduction through both small scale and large scale composting. For the small-scale, Waste Management promotes composting by holding workshops, consulting, and a newsletter releasing. For the large-scale, a composting facility located at the South Campus has been constructed. The UBC Compost Project seeks to provide ongoing education and information on composting to the UBC community in order to raise campus participation and awareness. The project monitors current composting projects and operations in order to determine whether they are operating smoothly (University of British Colombia, 2006).

Since 1997, Penn State project at the University Park Campus has composted food waste, manure and leaves. The wastes were collected at the composting site, a few miles behind the campus where manure from animal research herds, leaves from campus grounds were mixed with kitchen wastes. The finished compost materials have been used for flower beds and landscaping in the campus (Penn State University, 2000).

The University of New South Wales (UNSW) has established a significant on-site compost facility. This facility receives garden organics sourced from the UNSW grounds and food organics sourced from commercial food outlets and long day-care centres. These separated compostable organic sources have been processed on-site into composted mulch. This mulch is used in landscape maintenance practices on the UNSW campus landscape (The University of New South Wales, 2006).

3.2.3 On-site Wastewater Treatment Systems

The collection, treatment, and discharge of wastewater systems operated in or near the site where the wastewater has been generated are called on-site wastewater treatment systems. These systems are typically designed to treat between a few hundred and a few hundred thousand gallons per day. On-site technologies can range from high-tech membrane-filtration systems that recycle wastewater for toilet flushing in large buildings, to sophisticated designs that use ecosystems, such as constructed wetlands, to treat wastewater. On-site treatment can reduce construction, operations, and maintenance costs while conserving resources and providing an ecologically attractive feature for the site (Wilson, 2001).

In an on-site wastewater treatment systems the wastewater flow first enters a septic tank for primary treatment. Secondary, or more advanced, treatment can be handled by modified septic tanks with an anaerobic/aerobic treatment device or a specially equipped aerobic tank; specially designed filters, such as sand filters; constructed wetlands that rely on algae, microbes. On-site wastewater treatment systems may perform multiple tasks simultaneously. For instance, a constructed wetland provides both wildlife habitat and recreational opportunities (Wilson, 2001).

"Grey water" is wastewater collected from washing machines, bathtubs, showers, and laundry or bathroom sinks. If properly collected and stored, it can be safely re-used for irrigation, toilet flushing and other water needs. Grey water may contain food particles, detergent or soap residue, and possibly some human pathogens. But as a general rule, it does not require extensive chemical or biological treatment before being used for landscape irrigation. It is best to use grey water on ornamental plants and lawns, or to irrigate trees because it often contains nutrients such as nitrogen or phosphorus that plants benefit from (Waskom, 2006). It may also contain, however, sodium and chloride which can be harmful to some sensitive species.

Grey water may be immediately directed to landscaping, or it may be stored for later use. When stored, filtering the water is more important, to reduce the growth of any pathogens. Grey water should not be used for dust control, cooling, spray irrigation, or any other use that would result in air-borne droplets or mist and irrigation of food

crops. In some areas, reuse of water is either prohibited by health officers and plumbing inspectors, or requires an inspection and permit (Owens and Frazer, 2005).

Grey water systems vary from simple low-cost systems to highly complex and costly systems. The technology involved in such systems ranges from the sophisticated to the crude, from engineered systems with filters and pumps to a washing machine draining directly onto oleander bushes. Some of these systems are able to remove pollutants and bacteria from grey water. The better systems include settling tanks and sand filters (Figure 3.9) (Gelt, 2006).

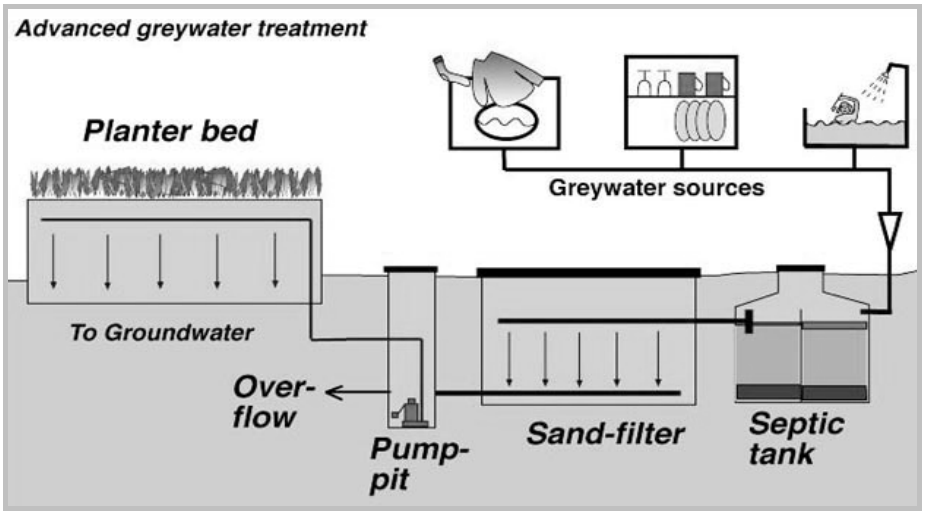

Figure 3.9: Grey water Treatment System (Lindstrom, C., 2000)

Humboldt State University in Arcata, California has decided to get involved with the idea of reusing wastewater. The Campus Centre for Appropriate Technology has designed the grey water collection and treatment system. The aim of the project is to catch and treat sink and shower water in a socially and environmentally responsible way, and to reuse the water and nutrients on site. In this system, grey water first drains into a filter from both the sink and shower and trickles down into a primary settling tank. With a lid above ground food, particles and grease get filtered into a mesh net and then settle. Filtered grey water then enters a distribution tank for entry into one of the two marsh treatment systems. Water is distributed uniformly across the surface of each chamber by a perforated pipe system. The pump below then pumps out clean and reusable water, which can be used for irrigation (Humbolt State University, 2002).

A Wastewater Garden was installed at the Centre for Sustainable Watersheds' Headquarters in Portland, Canada in July 2004 to treat wastewater and eliminate the need for pump-outs (Figure 3.10).

Figure 3.10: The Wastewater Garden at the Centre for Sustainable Watersheds' Headquarters in Portland (Centre for Sustainable Watersheds, 2005)

The Wastewater Garden is part of a new approach to looking at wastewater treatment by harnessing the power of ecosystem processes. This prototype will serve as a demonstration site to prove the technology for regulatory authorities, and also to research adaptations that might be necessary for the Canadian climate. The Wastewater Garden is a patented bio-engineered system developed by David del Porto of the Ecological Engineering Group in Massachusetts, from a concept originally conceived and tested by University of Toronto environmental engineering professor Alfred Bernhart. The technology has been approved and certified in Massachusetts since 1995 and there are now approximately 100 systems in use in the United States. The Wastewater Garden is a lined shallow bed filled with sand, crushed stone and gravel and planted with vegetation. Wastewater is pumped into the bed where naturally occurring micro organisms convert the chemical constituents of the wastewater into nutrients for plant growth by a subsurface distribution system. Once established, the system is designed to consume a daily load of wastewater (Centre for Sustainable Watersheds, 2005).

3.3 Materials for Sustainable Landscape

A sustainable campus landscape aims to use materials that have minimum impacts on environment and maximize outputs of resources that are reusable. For instance, rainwater harvesting and composting on a campus site can maximize the use of materials and resources efficiently while landscape planting can minimise the pollution and heat island effect directly. The materials that are used in a campus landscape should be minimally processed, durable and self-maintaining to satisfy the requirements of sustainability. Sustainable campus landscaping also attempts to minimize energy consumption and off-site impacts by considering the source of materials.

According to Dunnett and Clayden (2000, quoted Benson and Roe, 2000, pp.180-201) the best way to consider the sustainable use of resources and materials within a designed landscape is to consider the site as a functioning system, with inputs and outputs. Unsustainable systems (open) require high resource input and release large amounts of waste and energy. Sustainable landscapes (closed) aim to create systems to reduce direct energy and energy demanding resource inputs and maximize recycling materials and resources (Figure 3.11).

The positive impacts that can be achieved through planting and habitat restoration can unfortunately be easily made ineffective by a similar lack of sensitivity in detailing the built landscape. Potential damage caused by poor choice and use of hard landscape materials can easily diminish the positive effects of soft landscape materials. Thus, the hard landscape materials should be chosen very carefully. The choices made for the use of both soft and hard landscape materials for green design have a significant role in sustainable environment expectations in university campuses.

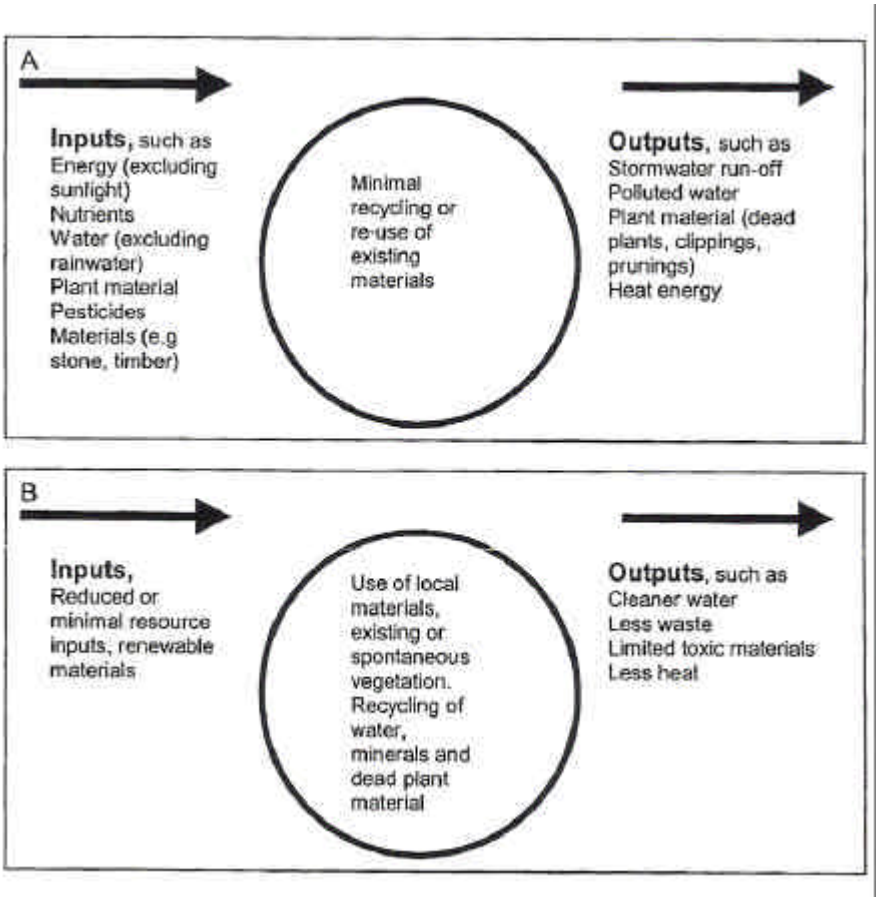

Figure 3.11: A Systems approach to landscape. A: an open, unsustainable system. B: a more sustainable, closed system (Benson and Roe, 2000, p.180)

In Indiana and Minnesota, two state parks have been designed with structures made from recycled milk jugs which are used as an alternative to wood. To celebrate Earth Day 1995, Harmonie State Park in Indiana built a viewing platform and four bridges from plastic lumber. The lumber was made from 150,000 recycled milk jugs, all collected from Indiana residents. The plastic lumber project not only supported Indiana's recycling industry, but provided a durable replacement for pressure-treated wood (EPA, 2005). In Anoka County, Minnesota, recycled plastic lumber has replaced wooden tables and benches in parks across the county, following a successful regional park pilot project conducted in 1995. Minnesota's Office of Environmental Assistance initially funded plastic lumber picnic tables, benches, tyre stops, planters, park signs, landscape edging, and a playground in Lake George Regional Park to test the quality of recycled-content products. Although each plastic lumber picnic table cost more, these plastic models are more durable than wood (EPA, 2005).

3.3.1 Soft Landscape - Plant Material

The selection of plant materials and the way that they are used have a significant impact on the sustainability of campus landscape. Plants have a major role in ecological functioning and sustainability of natural cycle. The following lists the functions of planting:

- Plants act as biological filters absorbing gaseous pollutants and heavy metals for pollution control and improving air quality (Dunnett and Clayden, 2000)
- The shading effect of trees around buildings and parking spaces reduces air-conditioning and cooling requirements
- Greening of walls can also reduce heat losses in winter, by up to 50 % of the exposed walls (Stulpnagel et al., 1990)
- Purification of waste water and storm water by creating wetlands provide significant wildlife and habitat (Dunnett and Clayden, 2000)
- Vegetation plays an important role in reducing carbon dioxide which results in the greenhouse effect and global warming at excessive levels
- Increasing the biological diversity of an area by planting different species can introduce wildlife and habitat to a site (Dunnett and Clayden, 2000)
- Reflecting or enhancing local distinctiveness through planting can help maintain ecological integrity and counter the trend for the specification of relatively small numbers of landscape plants nation-wide (Dunnett and Hitchmough, 1996)
- Planting can control erosion
- Planting can reduce noise

A key to creating a sustainable landscape has to include plants that are either native or well adapted to similar growing conditions of the site. Generally, they are less open to disease and insect problems, and provide better habitat for native wildlife than introduced species. These plants need less water, fertilizer, and pesticides. Plant survival with minimal maintenance is not the only issue in sustainability. It is important to know a plant's growth rate, expected life span, and whether it spreads around quickly. According to VanDerZanden and McNeilan (2001), significant plant selection criteria are plant hardiness zone, seasonal rainfall distribution, humidity,

soil characteristics, water availability, and duration and intensity of light. Every plant tolerates a range of conditions for each of these factors. “Shade trees are generally large-growing, long-lived, and native to their environments, making them best fitted for long-term use. Small flowering, ornamental and exotic trees do not last as long and require more care and more frequent replacement” (Yahres, 2000, pp.35-38).

Selecting plants carefully to minimize the amount of fertilizer, pesticides, and water required to keep them healthy is very important for sustainable landscapes (Fitzgerald and Ries, 1997). In addition, selecting plants that do not require extensive pruning to keep them in bounds can significantly reduce long-term maintenance costs. Pest-resistant plants also have an advantage of low maintenance. Reducing the use of invasive plants that might displace native plants, and disrupt natural ecosystems is another factor to be considered when selecting plants (VanDerZanden and McNeilan, 2001).

Plants can be analyzed in relation to ecological communities, botanical classifications, horticultural types, and esthetical considerations (Evyapan and Tokol, 2000). The selection of plant types for sustainable landscapes can be done according to their functional and ecological characteristics. Groundcovers such as turf, low-spreading shrubs, creeping plants and vines growing flat along the ground are low growing and surface covering plants. They can control erosion, absorb heat, moisture and dust, and provide different patterns (Evyapan and Tokol, 2000). Shrubs usually have more than one trunk and their height is between 90cm to 300cm. They can provide protection against wind and dust, create privacy and define outdoor spaces by forming boundaries, hedges and barriers (Evyapan and Tokol, 2000).

Trees are best used for shading and screening. The distinctive character of trees from other plant types is their trunk and height over a minimum of 3 meters. In terms of structure trees may be pyramidal, spreading, columnar, and round top. Broadleaved trees that are either deciduous or evergreen mostly provide shade. They are best planted at least 7 meters away from houses, buildings, or other obstacles. Shade trees can range from under 10 to 15 meters or even over 30 meters tall at maturity.

Ornamental trees are usually chosen for a particular characteristic, such as spring flowers, fall colour, an attractive bark, or crown form. These trees range from 10 to 15 meters tall at maturity. Small ornamental trees work well under utility lines or in

confined spaces. These trees should have a mature height of less than 15 meters. Conifer trees, "evergreens" that have needles or pin-like leaves usually stay green all year and are the best choice for windbreaks and privacy screens.

Some vines can be used to create "living" fences and walls, which often are more attractive and sustainable than concrete, wood or metal materials. Some of them twine around a structure while other climbers have thorns or hooks, tendrils, sucker discs or aerial roots to reach the light (Konemann, 1999). Walls of buildings or windows can be covered with vines to provide insulation or to reduce sun light (Evyapan and Tokol, 2000).

Herbaceous plants have attractive and colourful flowers and foliage. Perennials which grow back year after year from the original roots or from self-seeding, and annuals which grow for only one season and need to be replanted from seed or plants each spring are herbaceous plants. Their maintenance usually costs more than other types of plants, thus they can be used for specific spots requiring a smaller quantity.

There are also other group of plants such as cactus, succulents, ferns, palms, cycads, fruit and nut trees, herbs, vegetables, orchids and indoor plants that can be used efficiently in order to provide sustainable landscapes.

"The question of whether to use exclusively native species and exotics or mixtures of both in landscape plantings provokes much argument in U.S. and Australia, for example there are strong native plant organizations that promote the wider use of natives for landscape planting, and similar cases are being increasingly heard in UK" (Keddle and Rose, 1999 quoted in Benson and Roe, 2000, p.189).

Native species are easily adapted to the site, are cost effective and have low-maintenance. Planting of native species also enables the goals of increasing local distinctiveness and a sense of place. However, in sites heavily influenced by human activities, exotic species may be far better adapted than natives (Dunnett and Clayden, 1996).

3.3.2 Hard Landscape Materials

Concrete, brick, stone used for campus roads and sidewalks; wood, plastic, rubber used for landscape furniture such as playing equipment, benches and tables; metal and glass used for lighting, fences and gates; plastic used for irrigation pipes are examples of hard landscape materials. There are a few factors which should be considered before choosing the hard landscape material for green designing in campus areas. These are:

- Impacts of the material on the environment
- Maintenance requirements of the material
- Reusing and recycling opportunities of the material
- Cost
- Fitness for purpose
- Aesthetic qualities

The first three factors including impacts on the environment, maintenance requirements, reusing and recycling opportunities of hard landscapes are very important to sustainable and environmentally friendly designs. Hardscape materials vary in their effect on the environment. For example, pavement prevents water from soaking into the soil, thus increasing runoff which can carry contaminants into streams. Porous materials, on the other hand, allow water to soak into the soil (VanDerZanden, 2003).

Materials which can be re-used and recycled can be considered at the design stage. Some materials such as recycled plastics with wood by-products require almost no maintenance and last longer than wood. They can be used for decks, fences, benches, and planters.

Some of the recyclable materials are rubber, compost, metals, glass, paper, cardboard and plastics. There are many opportunities for using recycled materials in landscaping works. The use of reclaimed stone or brick, secondary aggregates,

recovered soils and organic composts or street furniture manufactured from recycled materials can help reduce the amount of waste going to landfill.

Tires and other rubber products can be recycled into flooring materials, low-grade industrial uses, road surfacing, speed bumps, and parking wheel stops. Recycled glass can be used for artworks, water filtration, glass flooring. Glass with concrete and asphalt additives also can be used as flooring material for pavements. Organic matter generated from food services and landscaping operations can be recycled to be used as compost. This not only reduces land filling but also provides a high-grade soil amendment.

Steel, copper, aluminium, brass, mercury, and zinc from appliances, light fixtures, cladding, flashings, plumbing, wiring, and structural materials are easily recyclable. They can be used for fencing wires, reinforcing bans. Materials made from recycled paper include new office paper and cardboard can be used as cellulose insulation, sound insulation board, drywall facing, and wallpaper (Wilson, 2001). Recycled plastics can be used in producing waste receptacles, office accessories, irrigation pipes and weather-resistant outdoor lumber products used for landscaping and furniture.

Campuses can become direct markets for more sustainable goods, such as energy efficient office equipment, environmentally friendly building and landscape materials, recycled furniture and office supplies, and organic food by using their purchasing power. Environmental labels provide information about a product or service in terms of its overall environmental character, a specific environmental aspect, or any number of aspects. There are environmental labelling schemes all over the world for almost every type of product, from paper to paints, and cut flowers to cutlery. Many schemes cover the same types of products (DEFRA, 2006). Environmental labelling supplies information about the products and creates environmental awareness among consumers, and provides an opportunity to choose products according to their environmental impact.

3.4 Water Management

Water is the world's most precious resource. Unfortunately, environmental problems such as climate change, pollution, population growth and uncontrolled developments cause water scarcity and degrade water quality. Increasing water scarcity requires the intelligent use and management of water resources to meet future water demands. Landscaping for water conservation, irrigation, wetland and stormwater management, rain harvesting, and sustainable drainage systems are the promising topics of sustainable and efficient water management.

Water conservation can be managed by appropriate landscaping. Landscape planning based on water efficiency is one of the best ways to preserve water. Within this part, various practices for water conservation such as xeriscaping, mulching, soil improvement, shading, site design with permeable materials, native planting, and maintenance will be assessed.

According to Robinette and Sloan (1984) there are basically three strategies of water conservation. These are:

- To use available water carefully and efficiently
- To design or redesign landscape with less water requirement
- To apply water to plants carefully and precisely

Water conservation can be maximized if it is considered in the initial planning phase. Landscapes can be divided into zones with different water requirements. There are 3 types of zones:

- Low water use zone
- Moderate water use zone
- High water use zone

In a low water use zone, plants do not need additional watering except when they are becoming established. Once turf or landscape plants are well rooted, natural rainfall

is the only water source used, even during drought periods. A moderate water use zone, permits water to be added during the period of establishment and at times of stress such as drought. In the high water use zone, water is supplied whenever the plants need it. These plants may not be able to survive even minimal drought stress without damage (Schrock, 2005).

In recent landscape design practices, “Xeriscaping” and “Native Planting” concepts are very popular. Xeriscape is an approach to water conservation related with landscape design based on water efficiency. The concept of xeriscape was developed in Denver, Colorado, USA, in response to water shortages (Thompson and Sorvig, 2000). Standford University in California has a garden serving as a showcase for alternative types of xeriscapes, the water-wise demonstration garden that contains a planting area of several lawn substitutes, a collection of California natives and a "Mediterranean" garden (Standford University, 2006).

Native planting is an approach to landscaping that uses naturally grown plants. Since native plants evolved to grow under local conditions, they do not need much support by watering except during establishment or regular chemical product application. Moreover, they do not require the same level of cutting and pruning maintenance as non-native plants.

Some of the landscaping practices that can be managed for water conservation are as follows;

- Mulching
- Soil analysis and improvement
- Efficient irrigation systems
- Site design with permeable materials
- Shading
- Creating heat barriers
- Plant selection-native planting
- Proper maintenance

Mulching is very beneficial in all water-efficient landscape zones. Mulching conserves soil moisture by blocking evaporation and also keeps the soil cooler. Mulching has the added benefit of reducing weeds that will compete for moisture in the soil. Many materials such as straw, pine needles, bark nuggets, wood chips and other wood products can be used for mulching. Thompson and Sorvig (2000) believe that landscape fabrics or black plastic landscape mulch can be used beneath organic mulching materials to provide better weed control and to increase mulch's ability to reduce water loss. They also suggests that rock mulches control weeds and hold moisture when used in shady areas. In sunny spots, rocks tend to absorb and release heat over a longer period of time, which can increase water loss from nearby plant leaves (Thompson and Sorvig, 2000).

Soil improvement is another important practice to conserve water in landscape. The better and deeper the soil preparation and improvement, the greater will be the plant's ability to survive. Plants in soils that are shallow or rocky or have a hardpan where roots cannot penetrate have poorer low-moisture endurance than those in deep, loose soils where roots can penetrate deeply and easily. Adjusting the pH level of soil, as well as improving fertility, may be necessary for establishing plants to ensure that they will survive under moisture stress (Schrock, 2005).

Shading can also be used for water conservation to reduce moisture loss by keeping surfaces cooler. Shade is particularly useful in hard landscapes near buildings to prevent water loss from nearby plants and soil. Plantings such as trees, shrubs and vines are used for shading as well as some structures such as trellises, canopies and arbours. According to Schrock (2005), although shade is very useful for conserving moisture, some plants can not tolerate it. In such a case using shade-tolerant groundcovers or other plant materials is more beneficial for water conservation. Shade is one of the ways to reduce heat increase on hard surfaces such as driveways, pavements or patios and consequently decrease water loss around them. Although, light-coloured surfaces trap less heat than dark surfaces, mulch or other organic materials create cooler places than light-coloured concrete or gravel. A barrier of plants between surfaces can break the heat flow from one area to another. This may ease the stress on some plants by reducing their water needs. Durable vines on fences with heat-tolerant shrubs can be beneficial for saving water and improving the survival of nearby plants (Schrock, 2005).

Site design by directing runoff from impervious surfaces (roofs or paved areas) to pervious areas (vegetation) is also important for water conservation. When surfaces are covered with impervious surfaces such as buildings, rooftops, decks, sidewalks, driveways and parking lots, less water can enter into the soil and the surplus of runoff increases. The increased runoff is usually channelled into ditches, drainage ways, storm sewers, or road gutters and often ends up in nearby lakes and streams (Thompson and Sorvig, 2000). The amount of runoff can be decreased with fewer pavements or with permeable materials to keep water in planted areas and to decrease the amount of water to be piped out from runoff channels.

Landscape maintenance is very important to keep plants healthy. Healthy plants are more drought tolerant than weak or damaged plants. Therefore, the control of disease or insect problems should be handled regularly, and damaged plants should be removed from the site. Fertilizers should not be used excessively because they cause pollution of streams and groundwater. Mowing grass at a proper height can help to conserve water. Pruning plants can also help water conservation by reducing the amount of foliage that is losing water (Schrock, 2005).

Cleveland University Master Plan has some guidelines for water conservation. According to these guidelines plant materials should be selected based on soil conditions, water requirements, and the size of the site. The use of native plants is encouraged. Diversity in plant materials is encouraged, particularly plants that grow naturally together and are self-sustaining. Plant species that require frequent maintenance and irrigation are discouraged (Cleveland University Campus Master Plan General Guidelines, 2005).

At Georgia Southern University native plants provide a strong sense of time and place. Species such as live oak and longleaf pine are intimately tied to the economic, cultural, and natural history of the region. Since native plants are adapted to the extremes of drought and heat that are common in south Georgia; they survive well, serve a variety of wildlife, and require minimum of water in this campus (Georgia Southern University, 2006).

The University of California Irvine's "Green and Gold Plan" identifies ways to better manage existing campus landscape assets and provides direction for future

development of landscaping that is environmentally suitable and sustainable. This plan supports native planting for water conservation.

3.4.1 Irrigation

The goal of landscape irrigation is to give plants a sufficient amount of water without waste. Use of efficient irrigation systems such as drip irrigation and sprinklers reduce the water consumption (Figure 3.12). Soaker hoses or trickle or drip irrigation are the most water-efficient systems. Overhead sprinkling generally is less efficient than watering at the soil surface or in the soil. During hot weather, considerable amount of water is lost by evaporation when overhead sprinkling is used (Thompson and Sorvig, 2000). Water requirements of plants vary during the seasons, thus programming the irrigation timer accordingly and using rain sensors can help to conserve water. According to Robinette and Sloan (1984) there are three determinants for the irrigation systems:

- Irrigation location relevant to plant types
- Amount of water needed
- Timing

By zoning an irrigation system, grass areas can be watered separately and more frequently than groundcovers, shrubs and trees. Irrigation time is also important to conserve water. Irrigation during the early hours of the day or at night is a factor in water conservation. Since automatic irrigation systems may cause overuse of water, rain sensors can be tied into automatic systems, or system can be controlled manually (Thompson and Sorvig, 2000).

Drip irrigation offers increased watering efficiency and plant performance when compared to sprinkler irrigation by slowly applying water to soil. The water flows under low pressure through emitters, bubblers or spray heads placed at each plant. Water applied by drip irrigation has little chance of waste through evaporation or runoff (Robinette and Sloan, 1984).

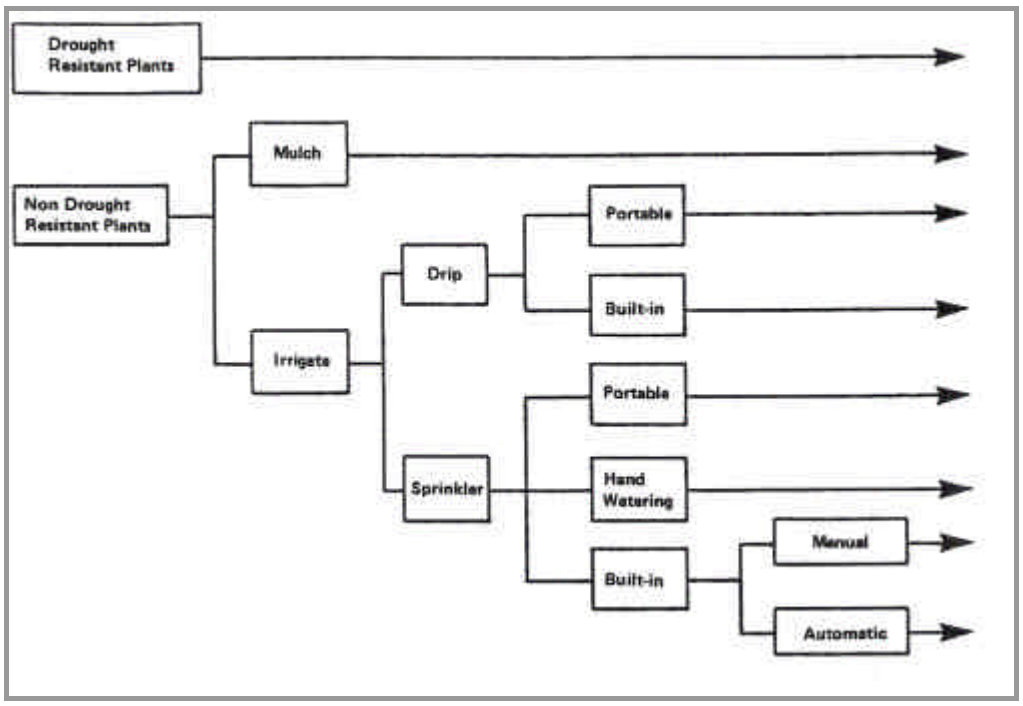

Figure 3.12: Water Application Decisions and Irrigation Types (Robinette and Sloan, 1984, p.200)

3.4.2 Wetlands and Stormwater Basins

Stormwater is water from rain or melting snow that does not soak into the ground but runs off into waterways. It flows from rooftops, over paved areas and bare soil, and through sloped lawns while picking up a variety of materials on its way. As it flows, stormwater runoff collects and transports soil, animal waste, salt, pesticides, fertilizers, oil and grease, debris and other potential pollutants. The quality of runoff is affected by a variety of factors and depends on the season, local meteorology, geography and upon activities which lie in the path of the flow (Marsh, 2005).

The Stormwater Management Wetland Demonstration Project at Cornell University aims to protect Cascadilla Creek from uncontaminated sediment due to soil erosion in stormwater runoff through natural gravity settling and to reduce the peak runoff of stormwater during storm events. The pond was constructed as part of a regrading and revegetation project to help prevent erosion on the side slopes of a former refuse dump and treat drainage from a large area upstream, thus enhancing a previously existing wetland environment (Cornell University, 2005).

Wetlands can be found alongside rivers and lake shores, and as lower altitudes in the landscape that often become flooded during storms. These wetlands are the natural stormwater basins of the landscape. According to the Stormwater Ecological Enhancement Project of the Wetlands Club at the University of Florida (2005) some of the benefits of wetlands and stormwater basins include:

- Habitat for commercially valuable fish and shellfish
- Groundwater recharge
- Recreational opportunities
- Aesthetics
- Improved water quality

The Villanova Stormwater Wetland in Villanova University Campus has been developed to reduce peak stormwater flows leaving the university. The goal of the project is to maintain the stormwater capabilities of the site, and to conduct research to determine the measurable water quality benefits of routing stormwater through a wetland habitat (NWF, 2003).

At Pennsylvania State University there is a project to reconnect Slab Cabin Run to its wetland floodplain. Reconnection to Millbrook Marsh will provide pollutant removal during rain and improve the functionality of Millbrook Marsh as a bio-retention wetland. The project integrates storm water management and nutrient reduction (Pennsylvania Office of the Governor, 2005).

The term 'daylighting' means to expose a culverted river, creek, or stormwater drainage in order to improve water quality and hydraulic capacity. With the impact of dispersed agricultural areas, roads and urbanization, surface water have been polluted and after they are diverted, straightened, confined in concrete channels, put into pipes, filled associated wetlands. Daylighting projects release waterways that were buried in culverts or pipes, covered by decks, or otherwise removed from view. Daylighting re-establishes a waterway in its old channel where feasible, or in a new channel threaded between the buildings, streets, parking lots, and playing fields now present on the land (Pickham, 2000).

According to Pickham (2000) some of the benefits of dayligting are given below:

- Exposure to sunlight, air and soil allows growth of aquatic and riparian vegetation that can improve water quality by taking up organic and inorganic pollutants.
- They can create wildlife corridors.
- Daylighted, open waterways often have greater hydraulic capacity than culverts.
- They can slow and infiltrate runoff, benefiting downstream residents by preventing flooding or erosion.
- They divert urban runoff from combined sewer systems before it mixes with sewage, reducing combined sewer overflows and burdens on treatment plants
- These projects save money in relation to the costs of repairing culverts.
- Open waterways can be more easily monitored and repaired.
- They provide recreational amenities.
- Daylighting projects can bring communities, businesses and governments together (can create better participation).
- The educational value of bringing aquatic and riparian ecosystems closer to students is an important benefit.
- Reconnecting people to nature is another important theme of daylighting.

The daylighting of Strawberry Creek at a park in Berkeley, California, took place in 1984. While other projects, such as in Napa, California and Urbana, Illinois re-exposed creeks in the 1970s, the Strawberry Creek project is widely considered the archetype of daylighting concept.

For 60 years, students and staff at North Carolina State University in Raleigh have been walking and driving over Rocky Branch Creek without being aware that a portion of the waterway was buried in the 1950s to maximize available land for building (Figure 3.13).

Figure 3.13: Rocky Branch Creek at North Carolina State University (Blankinship, 2005)

A 1950s-era master plan called for culverting all of Rocky Branch, and for 20 years the university worked toward that goal. But the operation was expensive, and the community became more aware of the effects of culverting in the 1970s, so the creek was never completely buried underground. Recently, North Carolina Sea Grant which is a partnership of various public agencies, including the university is working to reverse that environmentally misguided plan and improve the campus's stormwater-management program by daylighting projects (Blankinship, 2005).

The Stormwater Management Program at University of Virginia has aimed to ensure that stormwater generated on University property does not adversely impact the natural environment either on or off grounds. Newly constructed Dell pond is part of a larger Meadow Creek daylighting project that includes the pond, reconstructed stream channel and two floodplain areas representing a typical forested uplands floodplain and a typical Piedmont open floodplain (Figure 3.14). The goal of this project was to enhance the quality of Meadow Creek from both water quality and quantity perspectives. In addition, it has provided a park-like natural setting that can be enjoyed by all (University of Virginia, 2006).

Figure 3.14: Dell pond at the University of Virginia (University of Virginia, 2006)

3.4.3 Rainwater Harvesting

Rainwater harvesting is the collection and storage of rainwater from roofs, paved surfaces, and the landscape. Rainwater is collected directly in cisterns or recharged into the ground to improve ground water storage (Thompson and Sorvig, 2000). Some of the benefits of rainwater harvesting include:

- Prevents water wastage by controlling runoff
- Sustains and safeguards existing water table through recharge
- Increases water availability
- Improves water quality
- Arrests seawater intrusion and salination of groundwater
- Prevents soil erosion
- Mitigates floods

Queen Margaret University College's (QMUC) new campus at Craighall (UK) has a proposal for rainwater harvesting in line with the sustainable campus vision.

According to Nick Bowen, from Ian White Associates, the landscape architects responsible for designing the campus grounds the wetland habitat to be created will be an environmentally-friendly addition to the site for a number of reasons. The pond will capture rainwater draining off roofs and paved areas, holding it back on site rather than contributing to downstream flooding. So, as well as providing a solution to the problem of excess surface water, there will be an attractive feature that will provide a pleasant spot which can be used for recreation, and an habitat for wildlife (Queen Margaret University College, 2004).

The Metropolitan Water District of Southern California and the U.S. Environmental Protection Agency awarded five University of California engineering students a grant to construct a rainwater harvesting system on the campus. The goal of the plan is to water the campus lawns with collected rainwater by setting up downspouts, rainwater diversion, catchments and storage tanks. Currently, group members are building a prototype system on the roof of Bourns Hall that will collect store and use collected rainwater to irrigate the lawns around the Bourns College of Engineering at University of California, Riverside (University of California Newsroom, 2006).

3.4.4 Drainage

Sustainable Drainage is an environmentally friendly way of dealing with surface water runoff which avoids the problems associated with conventional drainage practice. Conventional drainage exacerbates flooding, causes pollution and is generally more expensive to install and to maintain than Sustainable Drainage schemes. Some of the benefits of sustainable drainage include:

- Allowing natural drainage to function in the landscape surrounding development
- Simple and inexpensive maintenance and implementation
- Prevention of pollution
- Conservation of wildlife habitat
- Control of flooding
- Recharging of groundwater

The Environment Agency in the UK advocates Sustainable Drainage schemes because they do not contribute to flooding, they encourage wildlife and provide visually attractive, and educational, amenities in the form of wetland habitat which is increasingly under threat in the UK (Sustainable Drainage Website, 2006).

3.5 Wildlife Habitat Preservation

Throughout the world, habitat loss is the leading cause of threat on species and their extinction. "Habitat is defined as the local environment of an organism. It is sometimes referred to as the environmental address of an organism, but more frequently it is thought of as a unit of space and its environmental features principally microclimate, soil, topography, water, available nutrition, and other organisms" (Marsh, 2005, p.380). Different habitats ranging from alpine at high elevation to aquatic and floodplains on valley floors are illustrated in Figure 3.15.

Today, the greatest loss of species is caused by habitat destruction. In order to save biodiversity, destruction of habitat should be prevented by preservation of natural resources, native planting and habitat corridors.

Preservation of natural features and environmentally significant areas can help to protect the habitat. When locating and planning new developments, means to protect natural resources and habitat should be considered and buffers between natural areas and development areas should be provided. Changes on topography, soils, and vegetation should be kept minimal to preserve land, water and soil relationships that are essential for sustaining flora and fauna, and their habitats.

Preservation of historic landscape can also help to keep both social and cultural values and habitat. A historic landscape is a geographic area, including both historic and natural features, associated with an event, person, activity, or design style. Natural areas can be utilized as educational areas for the community in order to establish environmental awareness and stewardship.

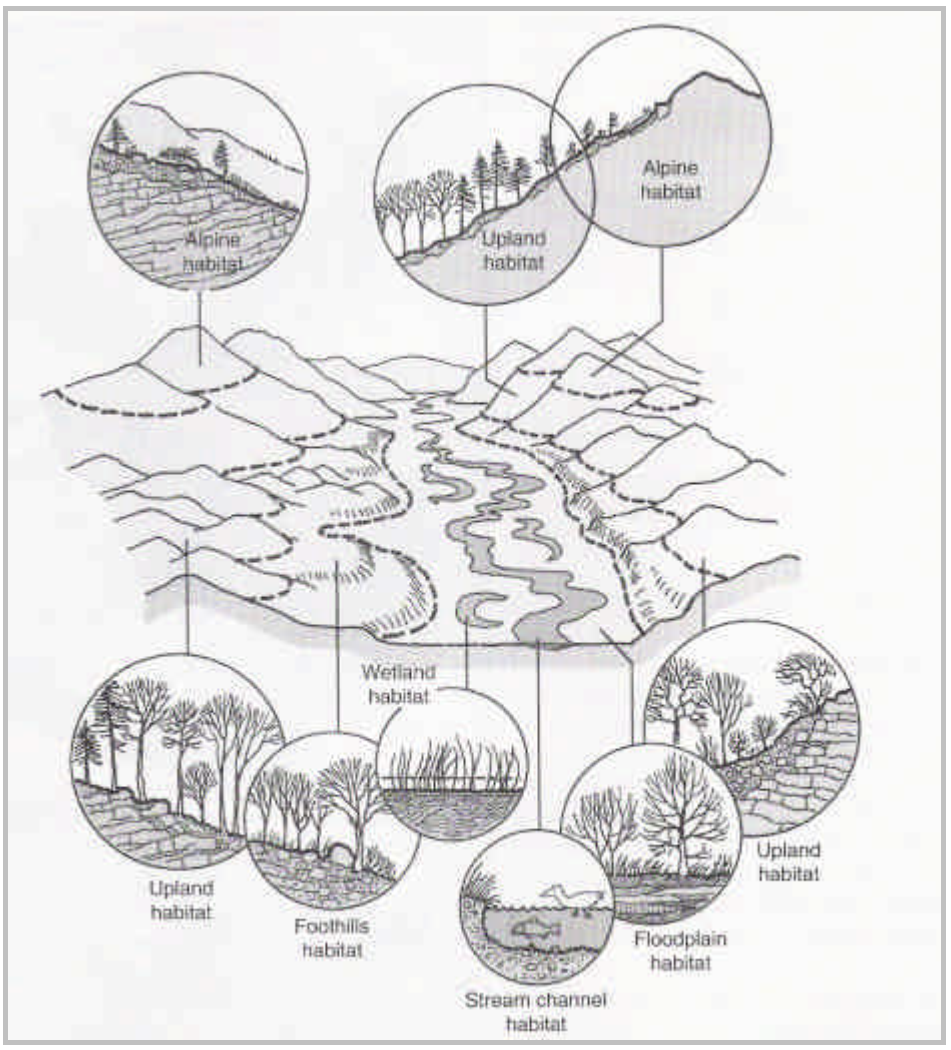

Figure 3.15: A schematic diagram illustrating the different habitats (Marsh, 2005, p.381)

Georgia Southern University's (GSU) Atlanta campus retains significant wetlands and forested habitats as a natural backdrop to campus development. GSU's strategic plan offers a greenway which is a wooded trail extending from one end of campus to the other. This is a creative way to link and preserve these habitats while providing the campus community many direct benefits such as education, recreation, aesthetics, and conservation (Georgia Southern Environmental Network, 2006).

Native Plant & Landscape Restoration Nursery at the Washington State University is a new campus ecology project initiated by faculty and students on the Pullman campus. The nursery provides teaching, research, and public education on ecological restoration, biodiversity conservation, landscape ecology, and the design and development of sustainable landscapes. One of the major functions of the Native

Plant Nursery is to provide plants for creating and restoring habitats on campus landscapes, as well as on public and private lands in surrounding communities (Washington State University, 2006). The nursery also works to conserve the biological diversity of one of the most endangered grassland ecosystems namely Palouse Prairie in the United States.

Native or indigenous plants naturally flourish in the region where they evolved. They are adapted to local soil, rainfall and temperature conditions, and develop natural defence mechanisms to many insects and diseases. They can grow with minimal use of water, fertilizers, and pesticides. Wildlife species evolve with plants; therefore, they use native plant communities as their habitat. Using native plants helps to preserve the balance and beauty of natural ecosystems (National Park Service, 2001). In 2002 during Environment Week, Oxford Brookes University's Wheatley Campus in Britain had 500 native trees and shrubs planted by volunteers and grounds staff. The trees and shrubs are all native species which provide a good habitat for wildlife (Oxford Brookes University, 2005).

Utilizing drainage ways, water channels, wetland areas, and connecting them together are the efficient tools to create wildlife corridors. By providing landscape connections between larger areas of habitat will create corridors to enable migration, colonisation and interbreeding of plants and animals. Corridors are the distinctive parts of the landscape connecting the parts to each other. They are continuous linear strips of vegetation and habitat such as river banks, ridge lines etc. They also may be parts of a larger habitat area selected for its known or likely importance to local fauna (Department of Environment and Conservation, 2004).

According to the Department of Environment and Conservation (2004), corridor management should aim to ensure that ecological processes and corridor function are maximised. Maintaining and increasing vegetation cover and habitat quality to maximise connection between larger remnants of vegetation will help dispersal of wildlife populations between larger remnants and ensure genetic interchange and seasonal wildlife movement. Providing specific habitat resources and ecological needs particularly for threatened species, and maximising corridor width and function by vegetation and control of weeds and feral animals can develop wildlife in the site.

3.6 Pest Management

Pest is any species that disrupts the normal function of an area by invading, destroying and spreading disease (Miller, 2004). Pest management consists of actions aimed at avoiding or mitigating negative impacts coming from pests to human beings, environment and the economy from pests. Using environmentally sensitive prevention, avoidance, monitoring, and suppression strategies to manage weeds, insects, diseases, animals, and other organisms including invasive and non-invasive species that directly or indirectly cause damage or annoyance is called pest management. A pest management plan can include: rate, method, timing, risk assessment, integrated pest management, appropriate mitigation, and recordkeeping stages (Pimentel, 2002).

Integrated Pest Management (IPM) is an ecology-based system of pest control that uses natural predators, pest-resistant plants, and other methods to preserve a healthy environment in an effort to decrease reliance on pesticides. In this management method a control program is developed that includes cultural, biological, and chemical methods applied in proper sequence and with the proper timing in order to prevent unacceptable levels of pest damage by the most economical means and with the least possible hazard to people, property, and the environment (Miller, 2004). According to Alston (1996) pest management should include the stages given below;

- Proper pest identification is essential for determining if control is necessary and for selection of the best suited control options.
- It is very important to look for pests and injury symptoms on a regular basis. Monitoring traps for insects, diseases, or vertebrates can be used when appropriate.
- The suitable pest control action must be taken to prevent unacceptable damage to the ecosystem.

There are some general tactics for integrated pest management such as cultural, mechanical, biological and chemical controls.

Cultural controls for pest management are land and water management, sanitation, habitat diversification, using disease resistant species, improving soils and fertilization. Maintenance of the ecosystem in a healthy state to minimize the

competitiveness of pests is important. In some situations water levels can be regulated to reduce pest problems (e.g., mosquitoes, aquatic weeds, etc.) (Alston, 1996). Plant parts and debris (prune, gather, burn) that can serve as protective or over-wintering sites for many pests should be removed. In monoculture situations (e.g., agricultural fields, orchards, landscapes, etc.), diversification of vegetation in the habitat may subsequently increase the diversity of animal life including pests in the habitat. Selection of insect and disease resistant species and cultivars of plants whenever they are available can provide cultural control for pest management. Proper fertilization is important, but over-fertilization can lead to excessive, lush growth that can be attractive to aphids and other foliage pests. Increasing organic matter of soil where it is low can improve the growth and health of plants.

Hand removal, moving, traps and physical barriers are some of the mechanical controls applied for pest management. Hand-pulling of weeds or other pests physically removes them from the site. Mowing weeds, especially before they produce seeds, can be a very effective management tool. Attractive traps can be used to mass trap and remove pests from the environment or to monitor their activity so that control actions can be appropriately timed. There are many types of physical barriers that can be used to block or disrupt the movement of pests. For example, sticky bands placed around the trunks of trees can prevent some mite and insect pests from crawling up into trees.

Many predators, parasites and pathogens occur naturally are continually working to regulate nature in balance and can be used as biological controls for IPM. The importance of "natural enemies" is often not appreciated until a broad spectrum pesticide, which kills many beneficial as well as the targeted pest, is applied and a new pest suddenly released from biological control becomes a serious problem. Avoiding the use of broad spectrum pesticides unless necessary, using selective pesticides, providing a habitat that is more favourable for natural enemies by choosing adjacent plants that supply nectar, pollen, alternate hosts, and structural protection, and providing adequate organic matter in soil to ensure good habitat for soil micro organisms that control a variety of pests can encourage the activities of biological control agents already present in the environment (Alston, 1996).

Pesticides are chemical controls for pest management. They intend to kill, or control pests including weeds, insects, rodents, fungi, bacteria, or other organisms. Pesticides include herbicides, insecticides, foeticides, fungicides, and bactericides. Some pesticides can accumulate in the food chain and pollute the environment. Species will differ in their sensitivity to any one pesticide, and the toxic effects may be very different from one species to another. This is a particular problem when insecticide use results in harmful effects on other species (Roberts, 2002). According to Miller (2004), some of the major problems with conventional pesticides are:

- They accelerate the development of genetic resistance to pesticides
- Broad-spectrum insecticides kill natural predators and parasites that help control the populations of pest species
- Pesticide usage by aerial spraying or ground spraying is not efficient. They mix with air, surface water, ground water, food and non-targeted organisms
- Some pesticides harm wildlife
- They can threaten human health.

Many types of chemicals used before the development of synthetic pesticides are becoming popular once again as alternative or "organic" pest controls. In addition, many new chemical products such as "biologicals" and "insect growth regulators" are being developed and made available (Alston, 1996). Some pesticide types are synthetic, organic and biological pesticides. Synthetic pesticides are human-made in the laboratory; chemically joined compounds or elements. Organic pesticides are derived from plant, animal, or naturally occurring rock or petroleum oil sources. Biological pesticides are subsets of organics that specifically refer to products developed from naturally occurring microbial agents such as bacteria, viruses, and fungi.

The University of Oregon's Integrated Pest Management Program includes a list of identified pests, monitoring methods, and approved treatment procedures and a sample treatment record. The goal of this program is to maintain pest populations below action threshold levels while insuring minimal human exposure to health risks, inflicting minimal hazards on the environment, providing for effective monitoring

through inspections and standardized record-keeping and evaluating the effect of the IPM practices (University of Oregon Integrated Pest Management Program, 2005).

At the University of Colorado at Boulder (CU) has a program to minimize exposure to toxic chemicals and pesticides. Integrated Pest Management (IPM) has become the main means of controlling indoor and outdoor pests on campus. From ants and cockroaches to dandelions and pigeons, CU is on the leading edge of reducing the use of harmful chemicals and volatile pesticides in buildings and grounds management through integrated pest management (University of Colorado at Boulder, 2005).

3.7 Landscape Maintenance

Landscape maintenance can be described as keeping a landscape healthy, safe and attractive. Landscape maintenance activities include vegetation removal; herbicide and pesticide application; fertilizer application; watering; and other practices such as annual plantings and harvestings, periodic weeding, snow removal, driveway and path maintenance, shrub pruning, lighting, fencing, runoff drainage, irrigation, protecting and improving the topsoil and plants. It also deals with local animals (including birds, rodents, reptiles, insects, and domestic animals or pets), and creates means to attract or repel them, as desired or necessary (City of Santa Barbara, 2006).

Maintenance of campus landscape and amenities in campuses are mostly managed by the facilities or groundskeeping services of universities. Some campus areas are divided into zones to be easily maintained by different crews of groundskeepers. The landscape and grounds activities of a campus may include planting, pruning, watering, mulching, mowing, fertilizing, pest control, lighting and irrigation systems, and the maintenance of amenities such as benches, litter containers, walls, fences and special features. At some universities, along with landscape maintenance crews, other departmental divisions, students and volunteers may participate in the maintenance and enhancement of the campus landscape.

Campus landscape management and maintenance programs vary in relation to the type of landscape materials being used on the site and design considerations. For instance, maintaining turf and grass takes the most time, but can be accomplished

with the least need for professional expertise and training, while arboriculture may require the greatest professional expertise but takes the least amount of time to maintain (Yahres, 2000). Staffing levels are an issue for campus facilities management departments, in whether the environment is managed with a short-term versus long-term mentality. Groundskeepers can provide different levels of maintenance quality depending on how much acreage is in each groundskeeper's area of responsibility. The lack of enough groundskeepers can cause a decline in quality of the landscape. Frequencies, schedules, quantifying tasks, establishing maintenance zones, staff involvement and monitoring are the most important and essential elements for campus landscape management plans.

The typical landscape requires many inputs: time, money, labour, water, chemicals, and fertilizers. Landscape maintenance activities such as plant trimmings and weeds, polluted runoff from the use of chemicals and fertilizers, and water lost by evaporation from plants and soils create waste as an output. Sustainable landscaping aims to minimize the input and output of maintenance applications (City of Santa Barbara, 2006). Green designing that considers sustainability at all levels is very important for maintaining the campus landscape. A good design can reduce landscape maintenance cost and effort because it creates landscapes that require less water, fertilizers, chemicals, pruning and mowing. Some of the practices for sustainable landscape maintenance are summarized in Table 3.2.

Table 3.2: Landscape maintenance for sustainable landscapes

Maintenace Practice	**Action**	**Purpose**
Mowing, Trimming, and Weeding	Using mechanical methods of vegetation removal rather than applying herbicides	To keep plants and soil healthy
	Mowing lawns with the mower at the highest setting	To keep the roots and soil cool, and reduce the amount of clippings
	Avoiding loosening the soil when conducting mechanical or manual weed control	In order not to lead to erosion
	Using mulch when soils are exposed	To control erosion
	Performing mowing at optimal times	To conserve water
	Pulling weeds especially by hand	
Irrigation	Using automatic timers	To minimise runoff
	Using popup sprinkler heads in areas with a lot of activity	To avoid damage to sprinkler heads
	Irrigating slowly	To prevent runoff
	Irrigating in the early morning hours or at night	To conserve water
	Applying water at rates that do not exceed the infiltration rate of the soil	

Table 3.2 continues.

Maintenace Practice	Action	Purpose
Pest Management	Reducing pest pressure by maintaining plant health	To prevent pest problems
	Mulching	To prevent weeds where turf is absent, fencing installed to keep rodents out, and netting used to keep birds and insects away from leaves and fruit
	Removing the plant damaged by microscopic parasites	To keep plants healthy
	Avoiding use of pesticides if rain is expected or wind speeds are high	
	Controlling and removing invasive plants	
	Training employees and the university community on the use of pesticides and in pesticide application techniques	To prevent pollution
Diagnosis and Treatment	Diagnosing the problems in plants and investigating all the possibilities for treatment	To treat plants appropriately
Using Fertilizers	Dumping fertilizers into soil	To use fertilizers more efficiently
	Testing soils periodically	To determine proper fertilizer use
	Sweeping pavement and sidewalk if fertilizer is spilled on these surfaces before applying irrigation water	To preserve water quality
	Reducing the use of high nitrogen fertilizers	To avoid excess growth requiring more frequent mowing or trimming
Using Compost	Using compost trimmings	To produce a rich soil amendment and reduce fertilizer requirements
	Collecting lawn and garden clippings, pruning waste, tree trimmings, and weeds	To recycle and use as compost
Pruning	Pruning plants carefully and regularly and avoiding excessive pruning	To decrease water need by plants and waste produced
Inspection	Checking for diseases and insects by inspecting all plant parts including leaves, stems and especially roots, which should be firm and light in colour	To keep plants healthy
	Inspecting pesticide/fertilizer equipment and transportation vehicles daily	
	Repairing leaks in the irrigation system as soon as they are observed	To conserve water
Maintaining Hard Landscapes	Checking and doing the construction work needed for campus roads, sidewalks, cycle routes, lightings, pools, sculptures, towers, bridges, benches and other furniture regularly	To use materials efficiently
Equipment Use	Using hand tools rather than power tools	To avoid damage to plants
	Using electric tools rather than gas tools	To prevent pollution
	Keeping power tools well-tuned	To prevent energy consumption

This table is adapted from Bousselot et al. (2005) and Thompson and Sorvig (2000).

Other maintenance practices are avoiding landscape wastes in and around waterways or storm drainage systems, aerating lawn areas annually, reapplying mulch as necessary, removing dead plant remains and monitoring the campus area by keeping records of the maintenance practices applied to the campus landscape.

3.8 Transportation and Parking

Motor vehicle travel to and from university campuses contributes significantly to local and regional air pollution, greenhouse gas emissions, traffic congestion and noise. Campus roads carry vehicular traffic to and from the campus entry and exit points to various campus destinations as well providing access for service and emergency vehicles. The heaviest volume is usually seen by parking areas, building entrances, pedestrian drop-off and pick up points (Dober, 2000). Promoting and encouraging public transportation other than the single-occupancy vehicle is the key to greening campuses with respect to land-use and transportation planning. Providing amenities on site that support and facilitate the use of public transit such as ridesharing, carpooling, and vanpooling can reduce the land area necessary for parking and vehicle circulation (Wilson, 2001).

There are a few practices for environmentally sensitive transportation planning given below. Other practices will be examined in this part under 4 different topics including parking areas, using renewable fuels, bicycle routes and pedestrianization.

- Good public transport services
- Ridesharing, carpooling and vanpooling
- Privileged parking locations for vans, vehicles for ride-sharing, and bus passes
- Providing campus shuttle services
- Working with the local municipality to provide safe pedestrian and cyclist crossings on adjacent streets and on routes leading to and from public transit stops or facilities can encourage cycling, walking and use of public transportation.
- Limiting on-campus vehicle parking by increasing parking fees
- Using renewable fuels

The pathway to sustainable transportation includes finding ways to reduce consumption of energy for transportation and using renewable energy opportunities. To reduce energy consumption whenever possible, walking or biking can take the place of vehicles. Proper maintenance, lower speeds, and new technology can improve the efficiency of the vehicles. Vehicles with properly inflated tires, and

regularly changed oil, are much more fuel efficient than ones that do not take these measures (Chevonki Foundation, 2005).

The University of London, UK, has introduced a Green Transport Plan that would help the University to contribute to the improvement of the environment by encouraging a reduction in energy use. The Plan would consist of a series of measures to reduce the level of unnecessary travel and encourage those who have to travel to do so in ways that minimise the environmental impact. Policies to be considered for the Green Transport Plan include, promotion of car-sharing and the availability of district car parking, encouragement of cycling, walking and use of public transport and identifying measures to reduce petrol consumption, investigation of alternative fuels. To date, secure cycle parking has been introduced in the Russell Square car park and showers for cyclists have been provided, with grant assistance from the Cycling Projects Fund (University of London, 2006).

The University of South Carolina (USC), Columbia operates the Carolina Shuttle every weekday, offering free transportation for faculty, staff and students. To aid in "clearing the air," the Vehicle Management and Parking Services has started powering several of its shuttle buses with a mixture of soybean oil and diesel fuel, called bio diesel (National Wildlife Federation, 2004).

3.8.1 Parking Areas

Parking areas are a landscape cover associated with all zoning and land-use types. Most of the universities in the world now provide more parking than in the past because of increased numbers of evening and commuting students (Wolf, 2004.)

Parking can be the single largest land use in a campus. Reducing the area assigned to parking can help to mitigate air and water pollution, provide more green space, and reduce the warming effect caused by asphalt-surface. Practices that can create more environmentally responsible parking areas include the following:

- Paved area reduction
- Paved surfaces shading
- Infiltrating road and parking-lot runoff in bioswales

- The planning of parking aisles that run parallel to the topographic contours, leaving sloped areas between parking terraces, and making runoff more sheet like and less concentrated
- Planting of trees
- Underground parking

One impact of paved parking areas is heat island effects. Some materials such as asphalt used for paving can cause heat build up over a parking lot on hot days. Reducing the amount of paved and impervious surface area can prevent air pollution and heat. Another strategy to reduce parking area impacts is to increase the amount of shade over paved areas. Vegetation lessens the microclimatic impact of solar radiation absorption of large dark surfaces of asphalt paving. Buffer plantings may provide visual screening of large areas of parked cars, but interior plantings are needed to provide canopy cover (Wolf, 2004). Trees also reduce the amount of stormwater that enters engineered drain systems from large paved areas. Rain water can soak into the soil and groundwater and then be taken up by trees. This water then evaporates back into the atmosphere. Bio swales and rain gardens are design features that can be installed in parking lots to control and treat water runoff. When drainage ways with gentle side slopes vegetate, bioswales can collect and slowly carry the runoff flow downstream. This is a self-maintaining system that physically secures both the structure and trapped pollutants (Thompson and Sorvig, 2000).

Cleveland University's Master Plan offers some guidelines for transportation. Accordingly, access to the University can be enhanced by promoting alternative transportation modes and by locating parking facilities strategically. Streets should promote bicycle and pedestrian usage and bicycle racks and storage lockers should be provided throughout the campus. Surface parking lots should be screened with landscaping to minimize their visual impact (Cleveland State University, 2005).

3.8.2 Bicycle and Pedestrian Routes

Bicycle routes provide alternative transportation, reduce traffic, save parking spaces, and make biking safer. They also provide recreation opportunities. About ten bicycles can be parked in the same space as one car, and this means less car parking is needed in a campus where cycling is common. Healthy, active staff and students

who cycle instead of driving to university can be more productive. For these reasons bicycle routes are essential to implement a sustainable travel plan in campus areas.

The activities to be considered for encouraging bicycle usage and designing bicycle routes in McMaster University's Master Plan (2002) can be given as an example. These are as follows:

- For cyclists, bicycle parking, change/shower and locking facilities should be provided in the campus (Figure 3.16).

Figure 3.16: Bike parking facility at the University of Oregon (University of Oregon, 2005)

- Bicycle routes to and through the campus should be improved and expanded in partnership with the local municipality.
- Designated on-site bicycling routes that are user-friendly should be provided and should be marked for visibility.
- Designating congested areas on campus as "bike-walking" zones, where people will walk their bicycles, rather than ride them, to ensure safe relationships between pedestrians and cyclists, and cyclists and vehicles
- Separated pedestrian, bicycle and auto lanes within roadways or separated bicycle paths should be created. (Figure) At street crossings, special crossing treatments should be utilized. Street parking of autos next to bike lanes should be prohibited where feasible.
- Sufficient bicycle parking in as close proximity as possible to building and open space destinations should be provided.

Pedestrianization can help to support a sustainable campus environment by encouraging people to walk. Pedestrian routes connect green spaces for recreational use and create open spaces for social interaction. Providing safe and clearly defined pathways across and around the campus are very important for campus planning. They include all entrances, pedestrian-friendly access to public transportation, all-weather shelters and well-lighted, secure facilities and routes.

The University of York, UK, supports cycling by having links to public cycle ways, having internal cycle ways linked to all areas of the campus, providing secure cycle parking, locking and shower facilities (University of York, 2004).

Michigan State University Bike Project is a project dedicated to transforming recycled bicycles into a fun, economical, environmentally friendly and healthy transportation alternative for the University campus community. The University's goal is to make bicycles available free to all the members of the University community (Michigan State University, 2005).

The Eckerd College, Florida master plan includes elements to transform the college into an environmentally friendly and sustainable place. One of the major principles of the plan is to strengthen the residential community of students in close proximity to an academic and social setting, giving priority to pedestrian and bicycle transportation. In 2003, 150 bikes of three different styles were distributed across the Eckerd College campus. The bikes are a way for the community to make the transition from a driving to a pedestrian campus. The bikes are available for anyone to use. Several bike racks have been placed at points on campus with the heaviest traffic load, such as the library, academic buildings, and near the dormitories (National Wildlife Federation, 2005).

CHAPTER 4. GREEN CAMPUS DESIGN FOR ENVIRONMENTAL AWARENESS AND CAMPUS MONITORING

> *"The learning and benefit to society of higher education forming partnerships with local and regional communities to help make them socially vibrant, economically secure, and environmentally sustainable will be a crucial part of successful higher education. Higher educational institutions have an obligation to support local and regional communities, making every action lead to community improvement"* (Cortese, 2003, p.19).

This chapter will focus on the significant contributions of the "greening" of campus landscape and operations for environmental awareness through environmental stewardship, educational gardens and monitoring and sustainability assessment.

The key to achieving a sustainable future is for colleges and universities to equip the next generation with the appropriate tools. As Cortese (2001) points out, "institutions of higher education bear a profound moral responsibility to increase the awareness, knowledge, skills and values needed to create a just and sustainable future". The role of colleges and universities must not be only educating the members of society, but also has to increase the public awareness concerning environmental issues and supporting the technology and the will to create a sustainable future. Many professionals and environmentalists emphasize that a university must act more responsible (Savanick, 2004). Talloires Declaration, composed in 1990 at an international conference in Talloires, France is the first official statement made by university administrators as a commitment to environmental sustainability in higher education. It encourages universities to engage in research and education towards a sustainable future and set an example of environmental responsibility by establishing programs of resource conservation, recycling and waste reduction in universities (Pike et al., 2003).

Demonstration of sustainable landscapes offers an opportunity for the community in universities and local level to change their perceptions and values and to improve environmental awareness. Higher education institutions can develop environmentally

responsible decision-making skills in faculty, staff, students, and community by focusing on green design practices, sustainable campus policies, campus assessments and monitoring, long-term master plans, energy and resource conservation, and a greener curriculum. Campus greening projects are often a student's first experience with social change, promoting greater consciousness and awareness (Breyman, 2000). The process of campus greening improves student consciousness and gives students a sense of excitement (Pike et al., 2003).

Understanding and consciousness towards environmental problems mean environmental awareness, or can be simplified as thinking "ecologically" or "green". The University of New York at Buffalo has a campus environmental awareness campaign with the slogan of "Think Green" which started in 1999. This program includes a series of visual resources such as posters, booklets, bookmarks, mugs, etc. and green partnerships with other campus organizations. Another component of this program is the UB Green website which functions as a gateway to campus environmental programs, policies, activities and groups (The State University of New York at Buffola, 2005).

The University of Maryland, College Park in U.S. initiated some actions to address its goal of promoting environmental awareness, education and training for the university community. These measures included maintaining a database listing all courses, programs, activities relating to the environment and environmental stewardship and providing students with real-life campus problem-solving opportunities by organizing internships, assistantships, and supervised studies in support of environmental stewardship. Additionally, the university cooperated with other student groups, institutions, organizations, and surrounding communities; and established a website that shares information and accomplishments with a global population (University of Maryland Environmental Stewardship Committee, 2005).

The eco-campus project at Sabanci University in Istanbul is a greening campus project to tackle with environment problems and increase environmental awareness. It aims to reduce resource consumption and recycling in the campus. Additionally, it targets to contribute global environmental awareness by encouraging organic products and campus forestation. Since 2002, Sabanci University has organised several environmental focused seminars, panels, exhibitions and concerts. Akasya

Youth Environmental Summit is one example where related environmental clubs, organisations and companies participate to the activities. The university carries out environmental awareness and stewardship programs under the title of Civil Involvement Projects (CIP). Students can take CIP projects voluntarily, however every student needs to complete one project before graduation. CIP encourages and executes a broad range of projects about education, human rights, disability and environmental responsibility (Bostanci, 2006).

Public involvement in green design landscape projects are an effective method of community participation and development in the management of natural resources. For higher education institutions to create a successful link with the local community is very important for the information exchange on environmental problems and possible solutions, and the success of green design projects. "There are budgetary dimensions to the use of volunteers and community participants, but the greatest value is the environmental progress of perception of people doing the work" (Kenle et al., 2000 quoted in Benson and Roe 2000, p.286). Hands-on innovative projects provide good education and research opportunities (Savanick, 2004).

Students and campus users have the chance to see and implement the techniques they have been studying through educational gardens and environmental stewardship practices. Monitoring and sustainability assessments serve as tools for evaluation of the environmental impacts of campuses. Campus Sustainability Assessment can be a powerful tool to promote environmental awareness and sustainability on campuses by performing environmental stewardship. Assessment process provides accurate measurements and definitions which are very helpful for the planning stage in order to determine short and long term goals.

Sustainable development has three dimensions; environmental-physical, economic, and social. All three has to be balanced and essential, and thus, they are all equally critical to long run sustainability. Social dimension of sustainable development includes population, education, democratization and governance issues. In the scope of this study, physical and social dimensions have been interpreted with green design. In this part, educational gardens, environmental stewardship and monitoring have been assessed for the social dimension. They have been evaluated to demonstrate the importance and tools of green design in campus landscapes.

4.1 Educational Gardens

> "*We learn in classrooms (space). We meet our friends on the quadrangle (space). We gather for commencement in theatres, at amphitheatres, or on lawns. The most memorable spaces, though, represent a common experience and shared consciousness. The spaces in between existing and new buildings become the venue for future events, ceremonies, and day-to-day comings and goings. A grand focal green is not the only spatial aspect of a plan worthy of mention. Small spaces in between buildings can offer a compelling welcome for pedestrians who thus enter into a larger green and into the greater campus. Every green space is a potential act of generosity*" (Craig, 2006).

Campus landscapes consist of valuable resources that can support and enrich the higher education. This part will explain and give examples of campus landscapes which have educational goals and objectives. "Educational Gardens" are simply campus landscapes that are used by students and all the university and local community for learning and teaching purposes.

Educational gardens may include demonstration and theme gardens, outdoor classrooms, botanical and horticultural gardens, arboretums, sports fields, etc. Some campuses have significant natural resources such as forests, rivers, wetlands, geologic formations adjacent or inside the campus area. Universities can also benefit from these natural resources as grounds for education. Education can be achieved even by spending time and walking through the campus. For instance, in some campuses the educational purposes of plant life is met by labelling specimens, charting their location, and providing maps for walking through (Dober, 2000). These facilities can be displayed in an arboretum or throughout the whole campus landscape.

The University of Plymouth, UK, has a partnership with the Eden Project. The University's Faculty of Science uses Eden's facilities for teaching and research purposes in botany, biotechnology, entomology, soil science and environmental analysis. Eden Project (Figure 4.1) launched in 2000 in Cornwall, UK, offers a demonstration site that provides great opportunity for research and education. The 50 meter deep crater in Eden accommodates thousands of important and beautiful plants. The world's two climate zones including the humid tropics (rainforests and tropical islands) and the warm temperate regions (the Mediterranean, South Africa & California) have been interpreted in this project. Additionally, the third zone is

"Outdoor Biome" Eden's temperate zone that thrives on the climatic advantages that Cornwall has to offer (Eden Project, 2006).

Figure 4.1: Eden Project in Cornwall, UK (Eden Project, 2006)

EcoVillage at Ithaca, US, is a good example of community and university collaboration to promote environmental stewardship and sustainability. The academic partnership with Ithaca College provides EcoVillage a strong educational mission. EcoVillage is one of hundreds of intentional communities around the world that are striving to create models of a more sustainable way of life, started in 1991 on 176 acres of land. The project comprises the construction of 60 energy efficient community-built timber-frame houses with straw-bale infill for 160 people. It also provides vehicle parking outside the residential area and creates pedestrian streets throughout the village. EcoVillage has also wide media coverage, including reports on TV programmes and newspapers. The other projects at EcoVillage focuses on the use of solar photovoltaics, green building, and wind power (Walker, 2005).

The demonstration garden serves as an on-site example of the campus greening and maintenance techniques and educates the community on environmental issues. Some demonstration gardens support and integrate teaching, research, and service relative to the needs of the departments, faculties, university and all the community. Water gardens, wastewater gardens, green roofs, historical gardens, technology gardens and

natural gardens can be called demonstration and theme gardens in relation to their purpose origin. Additionally, tropical, colour-based theme; miniature; naturescape; xeriscape; vegetable, herb, butterfly gardens and etc. are the examples of theme gardens.

The dramatic sense of place created in campus landscapes by hard and soft materials, plantings, and art features can be used and redesigned to show environmental problems, solutions and examples of green design applications. Gardens displaying energy conservation and production such as wind, solar and recycling gardens designed with recycled materials, or displaying recycled materials and showing the process of recycling have significant impact on the training programs of environmental sciences and green design applications. Conservation gardens such as wetlands, riversides, forests can display the history of the site and environmental problems and solutions that affected the area by demonstrating the changes in the ecosystems and showing the successful land management and green design practices.

Most landscapes would benefit from a mix of aesthetic objects positioned in space to amuse, inform, and direct. Campus gardens can be designed for art such as sculpture gardens and outdoor galleries for student, university or local community exhibitions and forums. Some designs treat the entire campus or a part of campus as a sculpture garden (Dober, 2000). Outdoor theatres where people come together and share ideas in a social environment are also important parts of campus landscape to promote green design.

The Sheldon Sculpture Garden at the University of Nebraska contains pieces from demolished Louis Sullivan buildings in an effort to reflect American art of this century and show an environmental conservation practice. Imperial Valley College in California relocated the region's oldest train station to the campus. The site is landscaped with native plants, displays of historical farm equipment and historic street lamps in order to give an open museum atmosphere and to provide education for the University and local community (Dober, 2000).

The outdoor sculptures in the University of Cincinnati Fine Arts Collection are situated primarily on two main campuses of the university, approximately 200 acres (Figure 4.2). The collection includes commemorative sculpture honouring the

accomplishments of important university figures, as well as works of contemporary sculpture related to the construction of new facilities as part of the university's master plan (International Sculpture Centre, 2006).

Figure 4.2: An outdoor sculpture in the University of Cincinnati, 1999 (International Sculpture Centre, 2006)

The National University of Singapore (NUS) has actively worked to promote environmental consciousness among its staff and students and set up a Campus Green Committee since 1997. The NUS's Campus Green Programme supported by the University administration, faculty and the NUS Students' Union, the Campus Green Committee (CGC) has been adopted as part of the University's footprint for the environment. The University has an initiative to create campus-wide theme gardens within the NUS Green Plan 2012 Action Programme. Environmental awareness will be achieved by educating University staff, students and members of the public who visit the campus. Currently, the Bird Plant, Fragrant Plant and Medicinal Plant Gardens have been established and other theme gardens - Heritage Plants, Butterfly Plants, National Flower, Tropical Plants, Economically Important Plants, Threatened Plants and Forum Park- are in the process of planning for the future (The National University of Singapore, 2004).

The Centre for Regenerative Studies at California State Polytechnic University (Figure 4.3) is a unique case that combines residential, agricultural, and educational functions. The mission of the centre is demonstration, and research of regenerative

and sustainable practices. The 16 acre site located between the main campus and a county landfill was developed to foster environmentally friendly examples of buildings and landscapes. The landscape provides aquaculture ponds, wildlife habitat restoration, garden terracing using recycled materials, a straw bale greenhouse and a Solar Park where electricity is produced.

The adjacent landfill is also a potential source of methane gas that could be used for cooking, transportation, and other purposes to replace natural gas. The series of earthen aquaculture ponds for wastewater treatment creates a central landscape feature to the project. Outflow from the ponds is received by constructed wetlands and some of the water is reclaimed for irrigation; eventually some portion of the water is returned to the ponds by means of a solar-driven pump. As a recycling project, recycled concrete slabs were broken and reused on the site for retaining walls, garden paths and patio areas. Alternative construction techniques have been experimented on the incubator greenhouse building by using straw-bale walls and cellulose ceiling insulation (The California Integrated Waste Management Board, 2004).

Figure 4.3: John T. Lyle Centre for Regenerative Studies, California State Polytechnic University (The California Integrated Waste Management Board, 2004)

The Centre for Alternative Technology (CAT) Visitor Centre in Wales, UK is another good example for demonstration gardens. The CAT's Visitor Centre, Europe's leading environmental display centre, which demonstrates the power of wind, water and sun and working examples of environmentally responsible buildings, energy conservation, organic growing and composting. Currently, CAT's the Waste and Recycling Display, the Energy and Power Display (Figure 4.4), the Whole Home Display, the Wind Pavilion and the Rocket Composter (Figure 4.5) are the main facilities that support green design. The Centre provides many educational opportunities for children, students and adults by organized visits, tours and various activities (CAT, 2006).

Figure 4.4: The Energy and Power Display in CAT Centre (CAT, 2006)

Figure 4.5: The Rocket Composter in CAT Centre (CAT, 2006)

The Duke University Wetland Centre transformed a degraded portion of Sandy Creek in western Durham into eight acres of wetlands containing areas of open lake, marshes, and bottomland hardwoods. This project was designed to improve Durham's water quality as well as provide teaching and research opportunities by providing a site for research on biological diversity, hydrology, mosquito control, invasive plant species and other environmental concerns. The centre works toward this goal by conducting, sponsoring and coordinating research and teaching on critical wetland issues (Duke University, 2006).

Outdoor classrooms can provide interest and resources for both personal and social education, and give students the opportunity of being and learning within the natural environment. Botanical gardens and arboretums, forests, preservation areas, and wild natural areas can play a significant role in environmental education as outdoor laboratories. These areas provide vast outdoor laboratories for the exploration of biology and environment. For instance, at the Washington State University, the E.H. Steffen Teaching & Research Centre Reforestation project has been ongoing for over 40 years. This campus forest is used extensively for teaching, research, and as a demonstration area for the public. It contains a variety of native plantings and other

introduced trees, shrubs, and flowering plants used as an outdoor ecological laboratory (Washington State University, 2006).

There are some educational achievements that can be gained by creating outdoor classrooms in a university campus. They can provide spaces for ecological and scientific studies of plants, insects, pets, and animals by using a diverse range of resources such as ponds, meadows, woodlands, and wetlands, and by constructing artificial habitats. Technology and design activities such as creating large models, furniture making, experimenting and testing new products can benefit from the nature and size of the space available outside (DFEE, 1999). The outdoor classrooms can be used for sport activities and art such as exhibitions of sculpture, modelling, painting, and music, and other performances using the materials developed or produced in the campus grounds. Natural or recycled materials can be used to make simple musical instruments, including drums and percussion instruments, reeds and pipes (DFEE, 1999). Even some board games can be adapted for the outside and mazes can be designed. Fields for sports and active recreational purposes can be used as outdoor classrooms as well. The Figure 4.6 shows the outdoor classroom in NC State University Campus.

Figure 4.6: Outdoor Classroom in NC State University Campus (Funkhouser, 2006)

When creating an outdoor classroom in a campus, some design elements should be implemented in consideration of the teaching and learning character of the space. For instance, minimising noise pollution by using trees and shrubs or a solid barrier like a wall, fence or earth mounds and using plants to mitigate air pollution may be

considered. Plants are more successful in filtering air pollutants, rather than noise. The deciduous species and certain conifers can be used for this purpose (DFEE, 1999). By site levelling and the planting effects of wind, heat and dust can be minimised and energy conserved. For outdoor classrooms, the creation of sheltered areas against wind, heat, and rain by planting dense trees and other plants, and the construction of roof canopies are also considered issues (DFEE, 1999). In addition, furniture such as lighting, seating, benches and tables should be located sensitively.

Botanical gardens are public places where a wide variety of plants are cultivated for scientific, educational, and ornamental purposes, often including a library, a herbarium, and greenhouses; an arboretum (The Columbia Encyclopaedia, 2004). An arboretum is a botanical garden devoted especially to grow woody plants. The traditional functions of arboretums include growing, testing and showing the best regional plants; introducing new species; supporting science; teaching and research and providing outdoor recreation (Dober, 2000). Arboretums may be spread throughout the campus, thus the community may become close to the environment and be informed about the natural features.

Botanical gardens consisting of the collection and cultivation of plants from all parts of the world provide experimentation in plant breeding and hybridization, the maintenance of botanical libraries and herbariums. The plants in botanical gardens are labelled, usually with both the common and the scientific names, and they are often arranged in cultural or habitat groups, such as rock gardens, aquatic gardens, desert gardens, and tropical gardens (The Columbia Encyclopaedia, 2004).

Not many higher education institutions in the world have botanical gardens and arboretums. Although extensive acreage is not required for these gardens, only some of the Universities which offer related education programs have these facilities. With an environmental and educational approach, a whole campus can be arranged as an arboretum by labelling trees, adding native and exotic species, giving information about the plants and organising walks.

The University of California’s botanical garden in Riverside campus supports the profile of a natural setting. Within walking distance of central campus there are trees, mammals and bird sanctuaries, rose and herb gardens and a bridge over a fish pond.

An outdoor classroom trail linked to these features since the 1970s by connecting different zones, labelling and putting information boards to explain the site's significant natural features (Dober, 2000).

At the University of Michigan there are a few green design applications for educational purposes and one of them is called as "Landscape Explorers". This is a program for elementary school children and uses both school grounds and the University Arboretum (Nichols Arboretum) and surrounding landscape to teach children how to read the landscape and the ways in which people and the land interact. The Nichols Arboretum represents an early public partnership between the university and the city to protect public open space and natural areas for the benefit of both. The Arboretum also provides participants with an exquisite site from which to study the Michigan landscape as historians, artists, and naturalists. There is also a native planting garden which is "Oak Openings Garden" in the Arboretum. The garden aims to educate people about a largely lost habitat, and inspire people to use more native plants in their own landscapes (Environmental Stewardship at the University of Michigan, 2002).

At the University of Istanbul, The Faculty of Forestry has a herbarium, watershed hydrology field research station, climatological station and Atatürk Arboretum for environmental studies. The herbarium consists of a collection of about 26 thousand dendrological, shrubby and herbaceous specimens for teaching and research purposes, including most of the forest tree and flora species collected in various ecological regions of Turkey. The Atatürk Arboretum (Figure 4.7), established in 1949, is a collaborative division of the Faculty of Forestry and the Turkish Forest Service. There are two small impounding reservoirs in the 445 hectares arboretum area (University of Istanbul, 2006). The Arboretum offers an opportunity for people to research, observe, and enjoy exotic and indigenous ornamental plant species and landscape.

Figure 4.7: Atatürk Arboretum, University of Istanbul

Greenhouses or winter gardens as part of botanical gardens or separate can also serve as educational gardens and do not need vast areas to be built. A greenhouse is a glass or plastic building where plants are cultivated. Natural sunlight comes in through glass or plastic panels and the ideal growing conditions for plants are provided by the control of temperature and humidity inside the building. In most of the university campuses that have arboretums or botanical gardens, greenhouses are established to grow plants and provide education and research for the maintenance of the plants in the site.

4.2 Environmental Stewardship

Stewardship is the concept of reliable management of the world's resources for the benefit of present and future generations and ecosystems. Environmental Stewardship is defined for environmental education purposes as voluntary commitment, behaviour, and accomplishments that result in environmental protection or improvement. Stewardship refers to an acceptance of personal responsibility for actions to improve environmental quality and to achieve sustainable outcomes. There is also a moral obligation in the idea of stewardship to protect future generations (Blowers, 1993). Using energy and natural resources efficiently; mitigating all kinds of pollution; decreasing the use of hazardous

chemicals; recycling wastes effectively; and conserving or restoring landscapes such as forests, wetlands, rivers and habitat corridors to improve the quality of ecosystems are some of the environmental stewardship practices.

According to environmental stewardship resources at University of Michigan (2002), stewardship goals are as below:

Resources need to be managed in a manner;

- financially responsible.
- compliant with the rules and regulations established by society.
- providing the facilities to perform the mission of better education and research.
- as sustainable as possible helping to ensure they are available for future generations.

Environmental stewardship in campuses can be practiced by individuals, groups, stakeholders, companies, communities, non-profit and governmental organizations. In higher education institutions, achieving sustainability through stewardship requires involvement at all levels of the community, and also necessary actions from students, staff and faculty members through to the executive level.

Environmental stewardship has become a priority with the emerging green design processes taking place in many campuses in U.S, Canada, UK and some other countries. It involves examining all elements of campus operations in order to identify environmental impacts and strategies for mitigating these impacts (Simpson, 2001). In addition, it provides awareness and a work force for green design applications in campuses. The success of a higher education institution's environmental stewardship approach depends on active involvement of faculty, students and staff through their participation in campus activities, monitoring, assessment, design and planning stages.

Many colleges and universities across the US have adopted environmental mission statements and stewardship programs. Slippery Rock University's (Pennsylvania) Sustainable Campus Initiative Plan is one of them, enabling students and faculty to be part of the decision-making process regarding important environmental issues like waste production, land management, and water usage. Some institutions are

branching out beyond their campuses, partnering with community organizations on issues such as watershed protection, recycling, and green technology. For example, Bryn Mawr College is working with community residents to clean up local streams and revitalize polluted ponds (ULSF, 2003).

Numerous case studies implemented by university communities describe specific campus efforts and programs which demonstrate green design projects. These projects are reported and granted by the National Wildlife Federation and can be examples of successful environmental stewardship programs (Table 4.1).

Table 4.1: Environmental Stewardship examples at some universities

University Name/Location	Project Goals	Year
University of Hawai'i at Manoa, Honolulu, Hawaii	Removing invasive species, restoring the ecological and cultural integrity of a landscape, engaging university students and local community members and supporting native Hawaiian knowledge and culture	2005
Eckerd College, St.Petersburg, Florida	Expanding and improving native gardens on campus, engaging campus and community members, increasing knowledge about the benefits of native plant landscaping and facilitating the integration into the campus Master Plan.	2005
University of California, Santa Barbara, California	The project includes restoring native grassland habitat with the support of campus and community members, establishing educational signage on local species and surveying local biota to support a campus biodiversity database.	2005
Southern Illinois University, Carbondale, Illinois	Establishing and maintaining a pilot fleet of free bicycles on campus and educating current and incoming students, staff, faculty, and community members about the economic, social and environmental benefits of cycling.	2005
University of Southern Maine, Portland, Maine	Establishing a permanent fund supported by student fees to implement and maintain biodiesel use in campus buses and conducting a greenhouse gas emissions audit.	2004
Cornell University, Ithaca, New York	Promoting environmental awareness through fashion design, art and popular media by connecting academic and professional designers to create organic, nature-inspired designs for use in fashion photography and for the production of a coffee table book.	2004
State University of New York, Albany, New York	Removing invasive species, reintroducing native plant species of the Albany Pine Bush and conducting educational outreach among campus and communities members about the importance of native species.	2004
University of North Carolina, Chapel Hill, North Carolina	Organizing educational seminars, field trips and Town Hall forums and securing the purchase of green energy shares for the University's Academic and Health Affairs campuses.	2002-2003

This table is adapted from National Wildlife Federation (2005) website.

Since environmental stewardship has various approaches and operations, it is very helpful to explain the actors of environmental stewardship in higher educational institutions. Faculty, students, staff, administrators, volunteer groups and

partnerships are the actors of environmental stewardship in university campuses. Faculty members can assist campus departments by identifying teaching strategies and learning opportunities that support the campus environmental stewardship goals. They can assign projects that reflect environmental problems at the university; participate in activities designed to promote campus sustainability; and use their expertise by working with campus organizations on environmental stewardship projects (University of Maryland Environmental Stewardship Committee, 2005).

Students are the most effective stewards of the campus environment and as part of their educational experience that they can participate in most of the campus greening projects including campus environmental impact assessments; landscape management and maintenance programs. Students can take part in campus projects and activities and learning opportunities that support the campus green design and environmental stewardship approaches as class assignments, contract projects, and as voluntary efforts. They can be involved in decision making processes by initiating discussions about the environment and by participating in environment related campus and community service through committees, ongoing programs and special events. They can also take a leadership role in environmental thinking and stewardship action.

University staff can encourage those around them to become more environmentally conscious by initiating environmental programs within their units, and setting an example that demonstrates environmental responsibility. They can participate in environment-related campus and local community service through committees, ongoing programs and special events.

Without a clear commitment and active involvement on the part of a college or university president, a campus environmental program will be ineffective. For this reason, top level leadership is also essential to achieving success in campus greening (Simpson, 2001).

Higher education institutions can take advantage of partnerships and collaborations by establishing relationships with corporations, non-profit organizations, other educational institutions, local school districts, and major federal laboratories, and departments for environmental projects. Partnerships refer to the formation of a

collaborative working relationship between two or more organizations such as governmental agencies, not-for-profit organizations, educational institutions, and the private sector. It may also refer to intra-organizational unions such as the science and anthropology departments.

In determining methods to promote green design through environmental stewardship educational reforms in curriculum, promotion of green design by using media, student projects, audits, internships, competitions and campaigns can be considered. "The curriculum is the core business of the university even though in many ways it is more difficult to address because of academic sovereignty," points out Saunders (quoted in ULSF, 1996). Since the early 1990s, there have been discussions about the need for the curriculum of universities to provide students with understanding about the environment.

A variety of declarations and action plans have enabled universities to share ideas and support about how to green the university curriculum (Thomas and Nicita, 2002). In addition to some compulsory courses, students may take courses about environmental issues, conservation of natural resources and prevention of environmental problems to gain environmental awareness and participate in greening campus projects throughout their education. Some researchers argue that sustainability education needs to be included in college and university curricula as part of the move toward sustainable development (Savanick, 2004).

Student projects are very important in environmental stewardship programs. At the University of Waterloo the student projects including energy, landscape practices, water conservation, waste management, recycling, composting, and green product purchasing provide the perfect opportunity to assess impacts, conduct auditing, monitor issues and implement green design in campuses. Waste audits which have been performed in campus libraries, cafeterias, classrooms, departments, residences from 1991 to 2004 by university students enable the university to review the results each year and promote changes accordingly (Kloosterman, 2004).

Auditing is common at many colleges and universities where student groups conduct an inspection and present it as a challenge to their school's leadership (Simpson, 2001). A campus environmental audit is one of the first steps toward helping

universities to develop an effective environmental policy targeting sustainability. An environmental audit is designed to pinpoint the most significant environmental impacts and their causes. Environmental audits can result in cost savings for a university by identifying areas where resources are overused and that warrant improvement (Callier, 2001).

Using universities' potential work force and giving opportunities to students to gain experience in campus projects to conduct internships have important role in environmental stewardship. Harvard Green Campus Initiative coordinated summer internships and 11 interns worked on seven projects across the Harvard University from June through August 2001. The program provided a new vision of how to address campus environmental sustainability to relate with the university's core mission, conserving financial resources and enhancing human resources. The program while also contributes to teaching and research outcomes (Powell and Sharp, 2001).

Questionnaires and surveys applied to a university community may be helpful to identify the environmental problems and related solutions from the community's perspective and the results can be used to direct environmental stewardship programs and green design projects. For instance, EcoHusky Student Group at the University of Connecticut organizes projects and events in coordination with the Office of Environmental Policy and other environmentally-oriented groups in the campus and in the local community. On the website of the EcoHusky Student Group the results of the questionnaire are presented to the community to assess their environmental awareness (EcoHusky, 2005).

The use of media is the most vital method to promote green design, provide environmental awareness and to get information from other practices. Websites, newsletters, reports and articles about environmental projects, accomplishments, and plans provide broad knowledge and networking opportunities. Brochures, booklets, posters, stickers with environmental notes on bins, boards and other daily used products are used for informing about the campus activities, explaining environmental issues, giving examples and defining recyclables.

Maps are also very helpful visual materials to disseminate information. Cornell University's Environmental Compliance Office developed the Environmentally Regulated Areas Map. It is a visual database of information including lands that are protected or regulated, species habitats, flood zones, soil types, and others. This resource is helpful for the planning and location of rare species habitat protection; stream classifications; public water supply protection; natural areas protection; wetland regulations. It also contains a checklist to identify projects with potentially significant environmental impacts to the natural environment. There are also maps and illustrations showing recycling points, bicycle routes, endangered species and gardens that direct and educate campus users.

Competitions, workshops, conferences, campaigns, forums can promote green design, provide participation in environmental volunteerism efforts and encourage a community to participate in environmental activities. Grants and various awards given by government, by the university itself and by profit or non-profit organizations to support environmental projects promote environmental stewardship, and help to develop awareness among students, staff, administrators, educators, and local communities.

4.3 Monitoring and Campus Sustainability Assessment

Understanding the social and environmental impacts of universities is the first step towards making fully informed campus decisions for a sustainable future. Monitoring and sustainability assessments are the most effective tools for evaluation of the environmental impacts of university campuses.

Monitoring is a significant element of the sustainable design process. "The function of monitoring is to tell the story of how the site has changed, is changing, and is likely to change. It continuously records and informs our actions and is the major vehicle by which" the site speaks to us" providing the information that allows the sustainable designer to work with the natural regenerative process inherent in the patterns of each landscape" (Thompson and Frederick, 1997, p.274). Understanding the local and global environmental impacts caused by universities and colleges has a major role in improving campus sustainability. Before identifying the most effective

solutions for the environmental issues, an examination of ongoing practices should take place in order to compare the present and the past, and to set goals for the future.

Monitoring is a scientific tool to examine how landscape systems in a campus area function. Building a campus database allows policies to be based on real science and helps to ensure that the most effective strategies are applied for green design. Monitoring gives recorded information for the master plan and landscape management programs. The creation of a campus site database through monitoring helps to understand the local mechanisms of the site, to see long terms trends, and to compare with other campuses that are implementing green design programs (Thompson and Frederick, 1997).

The indicators for monitoring are very important for obtaining detailed and comparable scientific results. Indicators give valuable information about the present status of the resources being measured, the rate and direction of change, highlighting priority issues and guiding policy formulation. They can facilitate access to this information for different groups of users and play an active role in improving policymaking processes (Winograd, 1999).

The Campus Sustainability Summits Report (2005) presents the main ideas and recommendations for a sustainable Cornell University campus. This report summarizes and gives examples of effective indicators with which Cornell University could start an indicators program for monitoring. These indicators are as follows;

- Total energy consumption (including electricity and heating)
- Energy consumption by source, locality, per capita, or square foot
- Greenhouse gas and other emissions
- Total water consumption and waste water disposal
- Water consumption per capita or square feet
- Total solid waste production
- Proportion of solid waste re-used, recycled, renewed or composted
- Proportion of green purchasing indicators, such as recycled paper and inkjet cartridges

- Use of public transportation and campus parking lots
- Average commuting distance or total commuting miles
- Number of green buildings
- Total amount of protected land
- Annual savings of campus sustainability-related initiatives
- Number of faculties, courses, and students focused on sustainability
- Funding for sustainability research
- Money donated to sustainability programs
- Number of students, faculty, staff, and alumni involved with volunteer programs
- Number of students, faculty, staff, and alumni involved with campus sustainability decisions

Harvard University has implemented sustainability principles to develop and maintain an environment that enhances human health and fosters a transition toward sustainability. Among these principles there are some elements that are related to monitoring such as "Establishing indicators for sustainability that will enable monitoring reporting and continuous improvement" (Harvard Green Campus Initiative, 2003-2005).

Sustainability assessment is a process to enable policy makers to integrate their decision making on projects, plans, policies and programs so that they are consistent with sustainability principles. Sustainability assessment differs from environmental impact assessment by addressing social and economic as well as environmental outcomes. At present, most sustainability assessment efforts involve considering environmental, social and economic factors separately (Office of Sustainability, 2005). The definition of sustainability impact assessment differs with methodological approach and content perspectives.

On the other hand, Environmental Impact Assessment (EIA) is a tool used to identify the environmental, social and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers. EIA is

a rapidly developing process which originated as a result of legislation in the US in the late 1960s. It was adopted by the EC in 1985 and by the UK in 1988 and now forms an integral part of the planning process for many types of projects (Cranfield University, 2006).

In Turkey according to the 8th Five Year Development Plan (2005), National Environment Action Plan (NEAP-UCEP) is prepared in order to address environmental problems. NEAP (UCEP) provides an environmental strategic guideline in sustainability for Turkey. The plan was started up in 1998 by the State Planning Organization of Turkey and the Turkish Government. The EIA has been in practice since 1993 in Turkey. There is no sustainability assessment before or after the construction of the campuses. In Turkey only EIA is considered and EIA directs the development and design of the campuses.

There are many other environmental assessment frameworks, protocols and programs such as blue print for a green campus, ecological footprint, Taillois Decleration, Clean Air Cool Planet, Campus Ecology Station, the Natural Step, ISO 14001 and ULSF Sustainability Assessment for University Campuses.

Greening the Ivory Towers project in Canada is a good example for monitoring, auditing and recording the impacts of universities. This project aims to increase the sustainability performance of universities through improved understanding of their ecological and social impacts, and develop a more coordinated, focused and holistic action plan for future developments and plans. In addition, this project aims to bridge the gap between students, academics and administrators by involving them in the assessment and implementation processes. The project is based on an academically developed Campus Sustainability Assessment Framework (CSAF), which was designed to help students assess campus sustainability by understanding the socio-economic and environmental impacts. The framework is a direct response to a common need by those involved in campus sustainability initiatives for a consistent way of measuring socio-economic and ecological sustainability in the campus. It identifies over 170 indicators. It is the most common sustainability assessment framework used in campuses across the world. A group of students at Concordia University in Montreal proceeded to conduct the assessment. The Sierra Youth Coalition (SYC) which is a youth organization working on sustainability in Canada

was influenced by the works of a group of students who conducted the CSAF at Concordia University in Montreal. Consequently, SYC launched the Greening the Ivory Towers Project (GITP), subtitled 'Academia to Action' in 2003 (SYC, 2006).

According to the CSAF, campus sustainability is assessed by looking at two sub-systems: people and ecosystems (Figure 4.8). The figure below shows the model of sustainability used by the CSAF.

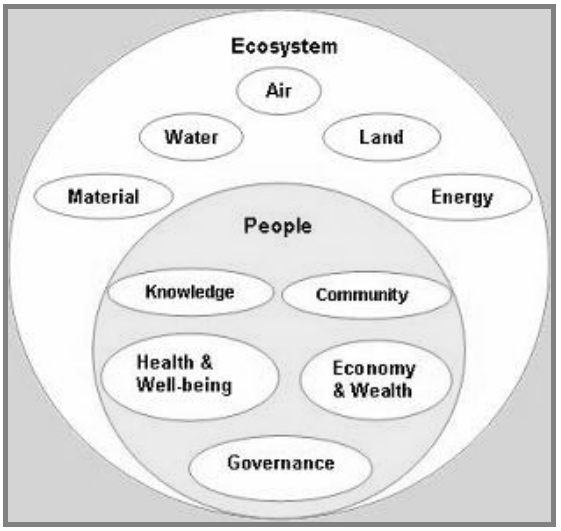

Figure 4.8: Sub-systems of Campus Sustainability Assessment Framework (SYC, 2006)

Within each of these sub-systems are five dimensions, representing the key campus sustainability issues identified by the framework's co-research team. These dimensions for ecosystems are air, water, land, materials, and energy; and for people are knowledge, community, economy and wealth, governance, and health and wellbeing. Each dimension is then further broken down into elements and sub elements until the organizational level of indicators is reached.

Campus Sustainability Assessment is completely necessary for the comparability of sustainability performances across the universities. It can be a powerful tool to promote environmental awareness and sustainability in campuses by performing environmental stewardship. The campus sustainability assessment is conducted at the early planning stage of a proposal. It should help to find out problems and establish a base on which to form the plans for the next step.

CHAPTER 5. EXAMPLES OF GREEN DESIGN APPLICATIONS IN UNIVERSITY CAMPUSES

Most universities have various initiatives toward sustainability in their campuses in order to contribute the prevention of environmental problems and to enhance the environmental quality. Green design applications, community involvement efforts and educational opportunities on environment determine the sustainability in campuses.

The university campuses which will be evaluated as best practices in this part have been chosen from different parts of the world according to the existence of green design efforts in their campus landscapes. These two universities are University of California Berkeley Campus (UCB Campus) and University of Nottingham Jubilee Campus. UCB Campus is located in the US where green design and environmental stewardship are very popular subjects. University of Nottingham Jubilee Campus in UK is a university which was designed and constructed in 1999 with green design approach.

For this study the master plans, landscape plans and environmental impact reports of the campuses have been used as resources. Of the universities chosen, only the University of California Berkeley Campus has a campus sustainability assessment that could help to evaluate the process of campus green design projects and further plans.

Firstly, brief information including location, land uses, landscape facilities, plans and sustainability history of the campuses has been given. Following this section, green design applications in these campuses have been examined.

Ten criteria have been determined in order to assess the green design applications and attain comprehensible results. These criteria are as follows:

1. Energy Conservation
2. Waste Management
3. Use of Sustainable Landscape Materials
4. Water Management
5. Wildlife and Habitat Conservation
6. Pest Management
7. Landscape Maintenance
8. Transportation and Parking
9. Educational Gardens
10. Environmental Stewardship

A table showing the projects and goals to provide sustainability in campus landscapes by implementing green design has been created for each university campus. Finally, planning activities such as landscape master plans, long range development plans, monitoring and management in these campuses have been evaluated in the last sub-section.

5.1 University of California Berkeley (UCB) Campus

The University of California, Berkeley (UCB), established in 1868, is a public, coeducational university situated east of the San Francisco Bay in Berkeley, California. UCB has undergraduate education programs and serves as a research centre for a broad range of disciplines. It has more than 130 academic departments and programs which are organized into 14 colleges and schools. Occupying approximately 1,232 acres of land, the campus is bordered on the west by downtown Berkeley, on the north by old suburban neighbourhoods, and on the east by the Lawrence Berkeley National Laboratory and the Berkeley hills. It is divided into the south and north parts by two branches of Strawberry Creek. It also contains numerous wooded areas including Founders' Rock, Faculty Glade, Grinnell Natural

Area, and the Eucalyptus Grove, claimed to be the tallest stand of hardwood trees in North America (Wikipedia Encyclopaedia, 2006).

5.1.1 UCB Campus Profile

UCB Campus contains Chaparral Hill and Claremont Canyon areas which are natural reserve areas of the campus for educational purposes. These are; Ecological Study area, Botanical Garden, Lawrence Berkeley National Laboratory, Strawberry Canyon Recreation area and Campus Park where the main educational buildings and facilities are also located. The Figure 5.1 shows UCB campus land use zones.

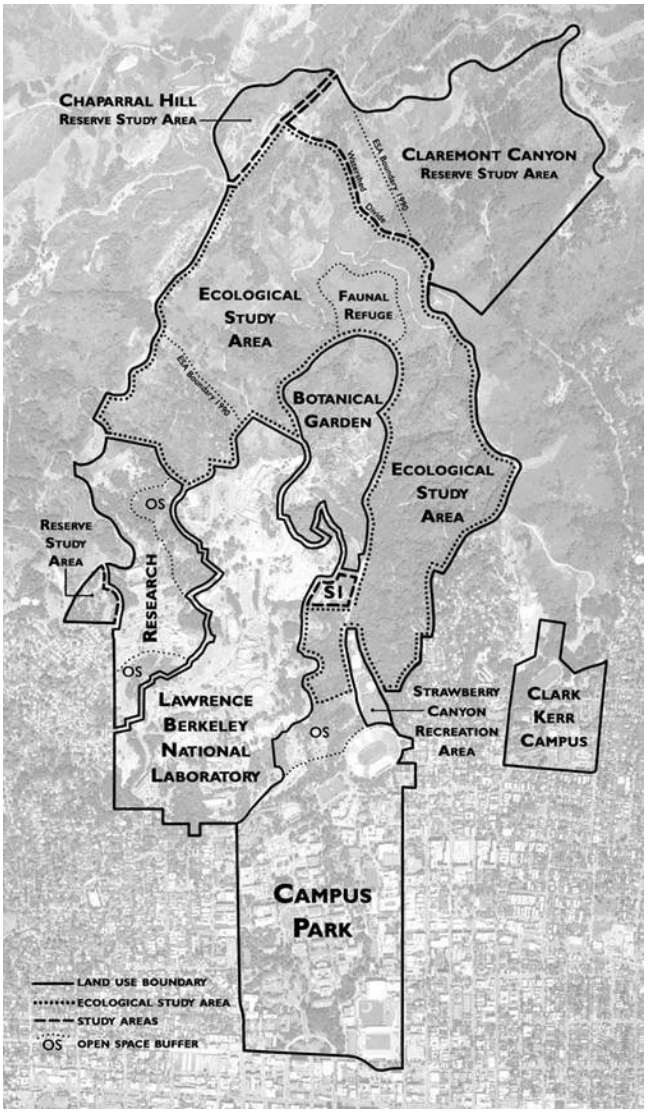

Figure 5.1: UCB Campus Land Use (UCB Campus 2020 LRDP, 2005)

UCB has two campus areas which are Campus Park and Hill Campus. The historic 180 acre Campus Park retains a distinctive park-like environment of natural and formal open spaces. The Hill Campus, over four times the size of the Campus Park, is a scenic and recreational resource for the entire East Bay, and is part of the continuous greenbelt of park and watershed land.

The Hill Campus consists of roughly 1,000 acres of land and Lawrence Berkeley National Laboratory comprises 200 acres of this land (Figure 5.2). The rest of the area contains several UCB facilities including the Lawrence Hall of Science, the Botanical Garden, the Space Sciences Laboratory and the Mathematical Sciences Research Institute. The Hill Campus also includes Strawberry Canyon Recreation Area and sport fields. The Figure 5.3 and 5.4 show Memorial Glade, Campanile clock tower and entrance gate in UCB Campus Park.

Figure 5.2: Lawrence Berkeley National Laboratory (Wikipedia Encyclopaedia, 2006)

Figure 5.3: Memorial Glade at the center of the UC Berkeley campus (Wikipedia Encyclopaedia, 2006)

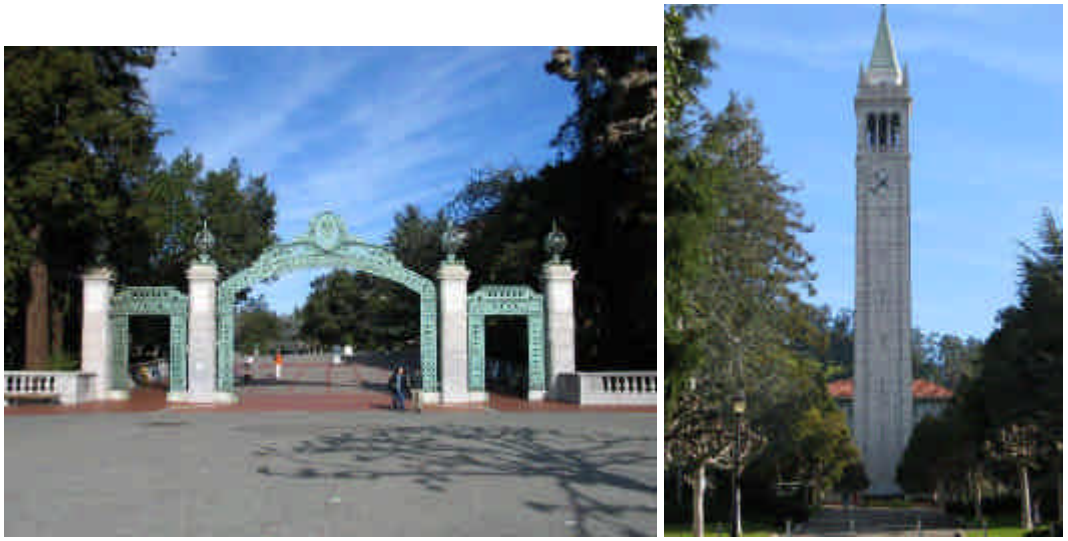

Figure 5.4: On the left entrance gate (a) and on the right Campanile clock tower (b) at UCB Campus Park (Wikipedia Encyclopaedia, 2006)

The UCB campus planning history goes back 150 years, and the differences in layout, size, materials and styles can easily be observed in the campus. In 1863 Frederick Olmstead designed the first campus plan with the influences of the City Beautiful Movement. Olmsted's layout was picturesque and informal with ample open spaces and paying special attention to topography (Figure 5.5a). Later, Olmsted's plan was set aside, and in 1869, Farquharson maintained the picturesque nature of Olmsted's plan, but organized the campus around a central axis dictated by

the creeks and terrain and in line with the Golden Gate. In 1901, John Galen Howard made a small alteration to the Emile Bénard's plan (1896-1902) which was a formal Beaux-Arts composition arranged around a central east-west axis with minor cross (Figure 5.5b) (Helfland, 2002). In 1927, George W. Kelham designed some buildings which were simple and classical in appearance, and oriented according to Howard's plan. After 1948, no supervising architect was appointed, and the office of Architects and Engineers were assigned to campus planning. In 1956, the first long-range development plan included issues such as parking, relationship between the city and the University, preservation of historic buildings, and campus landscaping. After the 1960s, the increasing numbers of students required more buildings and campus land. Therefore, new buildings were built in a variety of contemporary styles. In the 1980's and 1990's, the construction of new structures continued (Helfland, 2002).

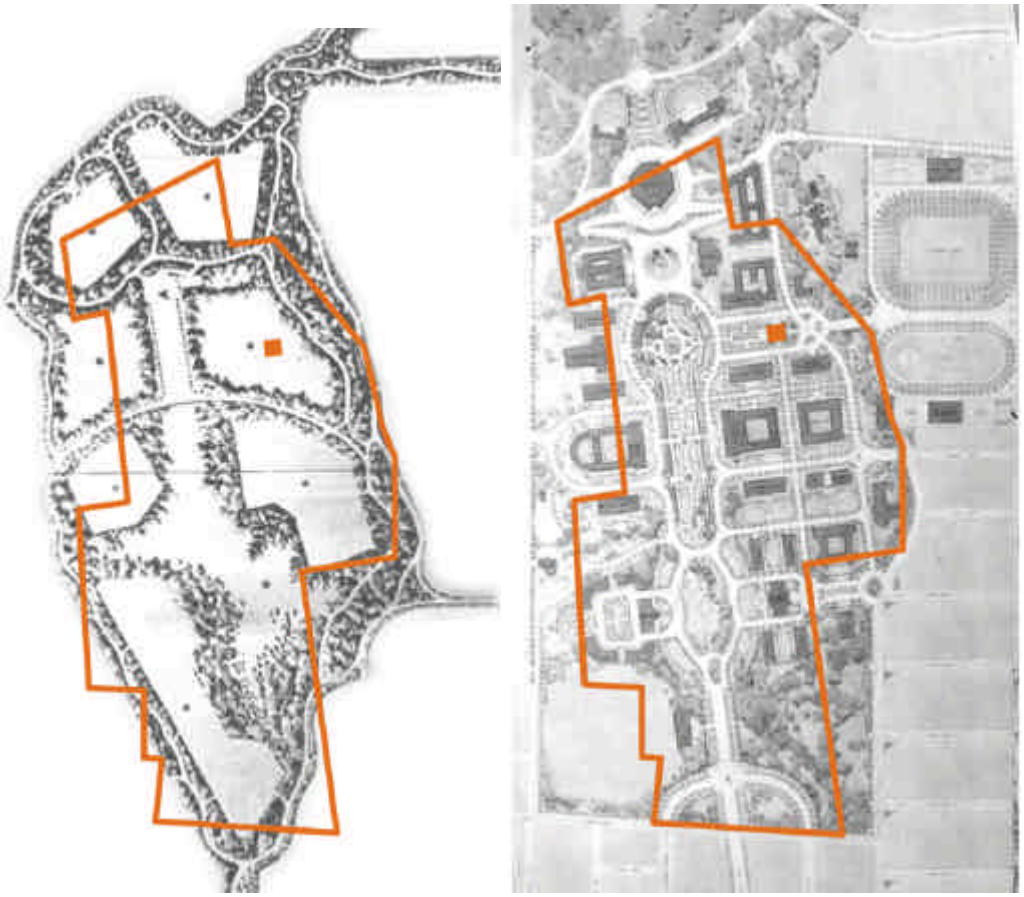

Figure 5.5: The Olmsted (a) and Howard (b) plans for UCB Campus. The orange square (Campanile) and outline (Classical Core) serve as orientation devices for each plan (Landscape Heritage Plan, 2006)

In 1962, the Long Range Development Plan (LRDP) was established in response to changing campus needs based upon a new vision of academic goals, student needs and conservation. UCB Campus Planning Office, in association with ROMA Design Group, implemented the 1990 LRDP, to preserve historic and natural resources, and move development and automobiles to the outside of the campus. In 2003, UCB's Landscape Heritage Plan and Landscape Master Plan which present a broad physical framework for the use and restoration of open spaces in the central campus, were developed (UCB Campus Landscape Heritage Plan, 2004). The planning time-flow for UCB Campus is as follows;

- 1860-1896 Berkeley Campus Development (Olmsted Plan, Farquharson Plan)
- 1896-1902 Phoebe Hearst Architectural Plan (Benard Plan)
- 1902-1927 John Galen Howard Plan
- 1927-1938 George W. Kelham Plan
- 1938-1948 Berkeley Campus Development
- 1948-1956 Berkeley Campus Development
- 1957-1980 Berkeley Campus Development
- 1981-1987 Berkeley Campus Development
- 1989-2005 Long Range Development Plan (LRDP)
- 1990-2005 Long Range Development Plan
- 2002 New Century Plan
- 2003 Landscape Heritage Plan and Landscape Master Plan
- 2005-2020 Long Range Development Plan

The history of environmental sustainability at UCB started with the Recycling Summit in 2001. After this summit other recycling summits have been followed. A Green Building Policy was approved in 2003 and the Berkeley campus has established an Advisory Committee on Sustainability. Then, Green Building Policy and Clean Energy Standard Steering Committees and California Student Sustainability Coalition were established. In 2005, the Campus Sustainability Assessment was completed to show achievements, monitored results and opportunities for the improvement of the campus environment (UCB, 2006).

5.1.2 Green Design Applications

There have been several completed projects and yet there are many to be completed in order to achieve UCB's goals to become a sustainable campus. The following section gives the details of these green design initiatives and accomplishments related to campus landscape planning. The UCB Campus has also extensive green building design studies which are out of the scope of this study. The UCB Campus's current green design applications and future plans and goals for campus landscape are summarized in the table below.

Table 5.1: Green Design Applications in University of California Berkeley Campus

Criteria	Green Design Applications
Energy Conservation	Campus solar project
	Solar panels
	Monitoring energy usage
	Energy awareness by communications on the web
	Further projects for use of renewable energy sources
Waste Management	Solid waste recycling
	Decreasing the waste going to landfills
	Indoor/outdoor recycling containers
	Re-Use Centre
	Green (leaves, brush and tree trimmings) waste recycling
Use of Sustainable Landscape Materials	Native planting
	Water-permeable pavements
	Use of recycled materials
	Green materials guide project
Water Management	Automated irrigation system
	UCB Water Protection Policy
	Strawberry Creek Management Plan
	Daylighting some parts of Strawberry Creek
	Construction Stormwater Specifications
	Water conserving stickers
	Drain labels
	Monitoring water usage, water audits
	Planting drought tolerant native species
Wildlife/Habitat Conservation	Strawberry Creek conservation
	Albany Village residential area conservation
	Richmond Field Station Stege Marsh brownfield restoration
Pest Management	Integrated Pest Management
	Reduction in pesticide and herbicide use
	Using mechanical or biological methods instead of pesticides
Landscape Maintenance	Improving soil conditions by mulching
	Use of tree cuttings as mulch around trees
	Automated irrigation system

Table 5.1 continues.

Criteria	Green Design Applications
Transportation and Parking	Transportation Modal split
	Less car parking
	Class pass and Bear pass systems
	Car pooling
	Parking limitations throughout the campus
	Electric charge stations
	Bicycle parking
Educational Gardens	Botanical Garden
	Economic Garden
	Agricultural Experiment Station
	Strawberry Canyon recreation and study area
	Ecological study area and faunal refuge for educational purposes
Environmental Stewardship	Campus Sustainability Assessment involved students, faculty and staff
	Strawberry Creek environmental stewardship project
	Chancellor's Advisory Committee on Sustainability
	University and Community Partnership Recognition
	Berkeley Alliance
	Annual meetings
	Student organizations

In 2003 policies for the Green Building and Clean Energy Standard were adopted by the UC Regents. The same year, UCB's first solar-electric system was installed on the roof of the Martin Luther King Jr. Student Union (Figure 5.6). The student-funded system is capable of generating up to 59 kilowatts of electricity at peak times (enough to power 60 homes) and provides for approximately 3% of the building's energy use. Campus solar project plans to meet UCB's electricity demand through on-site generation by 2014 (UCB Campus Sustainability Assessment, 2005).

Energy awareness has been disseminated through internet communications. In 2001, memos provided information on campus energy use and costs, and requests of conservation measures were implemented to reduce energy use in daily operations which were sent to all university faculty and staff by e-mail. Monitoring of the three main campus buildings started in 2004. The campus buildings' energy consumption was monitored by providing monthly charts on energy use to building managers and department heads (UCB Campus Sustainability Assessment, 2005). Then, meetings

were also held with managers to provide education and suggestions for energy conservation plans. In January 2005, the UC Board of Regents approved the 2020 LRDP in which the University's energy sources, consumption and resulting effects on outdoor air quality and greenhouse gas emissions were included (UCB Campus 2020 LRDP, 2005). Linking environmental studies to campus practices and increasing use of renewable energy sources are some of the future projects to improve energy conservation at the UCB Campus.

Figure 5.6: Solar Panels in UCB Campus (UCB Campus Sustainability Assessment, 2005)

UCB has notable applications and programs of recycling and reusing wastes. Since the late 1990s, the UCB has both increased solid waste recycling and decreased the tonnage going to landfills. The number of indoor/outdoor recycling containers for paper, beverage containers, green waste (e.g. leaves, twigs, grass and pallets), and metal has been increased, and access improved to make recycling more convenient for everyone in the campus. Re-USE Centre, which is open to all the university community, aims to divert 20-30 tons of reusable materials from landfills annually (UCB Campus Sustainability Assessment, 2005). Green waste recycling has been highly effective, collecting an estimated 18 tons per week. Leaves, brush and tree trimmings as well as other compostable materials are collected in conjunction with other grounds-keeping activities, and mobile green waste bins are available to campus gardeners (UCB Campus Sustainability Assessment, 2005). Choosing reusable and recyclable products, creating a database for reusable products, and

improving frequency and accessibility of recycling receptacles are future plans for waste management in the UCB campus grounds.

The landscape of UCB Campus contains mostly native plants suitable to Californian climate (UCB Campus Landscape Heritage Plan, 2005). Campus Park Guidelines of the 2020 Long Range Development Plan provide recommendations and guidance for planting with similar water need characteristics. Plant drought-tolerant native species is planted especially in areas around buildings to reduce water use and to provide "rain gardens" which can filter stormwater from building roofs, create essential habitat for birds and reduce maintenance costs (UCB Campus 2020 Long Range Development Plan, 2005).

Automated irrigation controllers with repetitive cycles and low-volume heads have been installed since the 1980s. The automation of campus irrigation reduced 15% irrigated water use from 2002 to 2004. Supervisory Control and Data Acquisition currently serves approximately 75% of the irrigated area at the UCB Campus. Installation of drip irrigation systems with moisture sensors which are extremely efficient is in the implementation process (UCB Campus Sustainability Assessment, 2005). Recently, redevelopment of Albany Village residential area in UCB Campus Hill has included plumbing that will allow use of recycled wastewater for irrigation.

Water Protection Policy, completed in 2004 prohibits dispensing pollutants into the creeks and provides the materials and labour necessary for implementing pollution prevention. Reducing the amount of chlorinated hydrocarbons entering the sanitary sewer, development of campus drain disposal guidelines, education programs, and implementation of a mercury reduction program brought an award from the California Water Environment Association in 2004 (UCB Department Safety Coordinator, 2004).

Water-permeable materials have been used in Sproul Plaza (Figure 5.7) redesign to improve safety and reduce stormwater runoff in the campus (UCB, 2006).

Figure 5.7: Sproul water feature and pavers in UCB Campus (UCB, 2006)

Water conserving stickers in residence halls, personal student water audits, and drain labels indicating the storm drains flow to the bay ongoing projects. The following list, according to UCB Campus Sustainability Assessment and 2020 LRDP, shows future plans and opportunities for water management in the UCB Campus.

- Construction of water recycling plant that purifies wastewater and serves as an education opportunity for students and the community
- Installation of an onsite biological water treatment system for all campus wastewater; implementation of on-site stormwater treatment design techniques such as curb cuts, planter boxes under rooftop drains, rain gardens in small drainage areas such as parking lot islands, and green roofs
- Construction of bioengineered crib walls, containing vegetation with indigenous materials such as wood or stone, to prevent erosion into the Strawberry creek
- Creation of swales in all parking lots that will filter and prevent water mixed with accumulated pollutants from entering the creek
- Increasing planting of native vegetation to improve water quality and to create additional habitat for flora and fauna by filtering organic chemical and bacterial pollutants from stormwater

- Daylighting the culverted parts of Strawberry Creek to provide more Strawberry Canyon wildlife habitat and more creek side open space on campus.
- Adding an educational interpretive feature that describes the history of the old waterfalls
- Replacing campus paths and roads with permeable pavement
- Installation of more green roofs on campus facilities, like the ones over the Northwest Animal Facility and the adjacent parking garage, to absorb rainfall and decrease associated surges of stormwater into the creek
- Utilizing open spaces in the campus such as lawns by converting them to swales and effective filters for storm and runoff water.

The campus includes a large amount of undeveloped natural open space that serves as a habitat for plants and animals, including some rare or endangered species, and provides opportunities for environmental studies and aesthetic enrichment. "The water available for domestic supply from Strawberry Creek was one of the deciding factors in locating a campus in Berkeley. However, development of the City of Berkeley since the 1860s has gradually altered the creek's water quality, habitat and hydrology. By the 1980s, the creek was considered a public health risk due to chronic sewage pollution. In 1987, UCB implemented the Strawberry Creek Management Plan to repair old plumbing affecting the creek and implement other pollution prevention practices" (UCB Campus Sustainability Assessment, 2005, p.81). By then, water quality had improved and today the creek supports several native species (Figure 5.8).

Strawberry Creek Management Plan includes source pollution control, aquatic and riparian habitat stabilization and restoration, and watershed management. Since 1987, implementation of this plan has led to substantially improved water and habitat quality and biodiversity, increased environmental education for students and the campus public, and has stabilized erosion in the most critical sites. Storm Water Management Plan and Construction Stormwater Specifications implemented in 2002 by including measures for pollution prevention in construction operations (UCB Campus Sustainability Assessment, 2005).

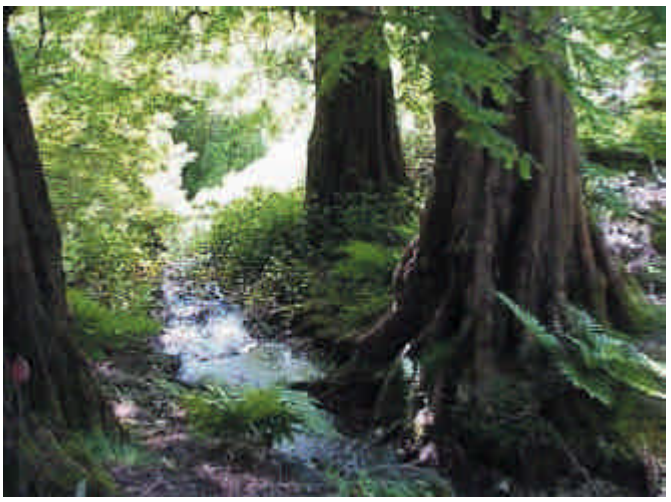

Figure 5.8: Strawberry Creek in UCB Campus (UCB, 2006)

The development of Albany Village residential area has received national attention and will help preserve the habitat in the newly restored lower Codornices Creek, home to the endangered steelhead salmon. In this area, innovative stormwater measures have been implemented and grassy swales, which regulate flow and treat pollutants in run-off, are designed. Nine acres of Richmond Field Station Stege Marsh, is being restored from an industrial operations area in order to increase habitat of protected endangered birds, other rare plants and animals (UCB Campus Sustainability Assessment, 2005).

Other projects related to wildlife and habitat preservation for the future are; planning for natural habitats by developing more natural green spaces, specifically designed for re-introducing native plants and animals to the campus; introducing more riparian habitat along the creek to replace the ivy which is an invasive plant.

UCB Campus implements Integrated Pest Management (IPM) for pests in and around structures while the campus is moving toward reduced toxic pesticide and herbicide use. In recent years, pesticide use has been reduced, with more attention being directed to prevention of exposure to people and sensitive ecological receptors, and prevention of water pollution in the campus (UCB Campus Sustainability Assessment, 2005). In 2001, UCB Campus was recognized by the National Wildlife Federation in their national report card for exemplary lands and grounds management. Currently, weed control and re-vegetation at the Richmond Field Station is being accomplished primarily through sustainable, non-pesticide methods

such as hand-pulling and covering with plastic by using volunteers and school groups. According to UCB Campus Sustainability Assessment (2005), the future opportunities for pest management are creating a habitat for natural predators of pests, such as owls and raptors; expanding use of biological control; substituting pesticides with less toxic alternatives; tracking pest control data electronically and altering the environment to facilitate pest control goals. For instance, rats eat ivy and use it to access rooftops, so the reduction of species like ivy can provide another alternative means of pest control in UCB Campus.

Maintaining campus lawns by applying synthetic fertilizer at the minimum amount considered necessary, using tree cuttings as mulch around trees to both reduce the occurrence of weeds and fertilize the soil, and applying mulch to help control weeds and improve soil conditions are some of the landscape maintenance practices have been implemented in the UCB Campus. Most of the campus's irrigation system is managed by a centralized computer system, making it more efficient naturally and cost effective. In the future, UCB Campus is planning to use reclaimed and recycled water for irrigation. Sustainable grounds management has aimed to increase planting of low water use plants to minimize irrigation water needs. In addition, using nitrogen rich compost instead of synthetic fertilizers to reduce costs and improve soil quality is another goal to be achieved by UC Berkeley's landscape management (UCB, 2006).

UCB has been implementing the Transportation Modal split assessment which is used to evaluate the use of alternative forms of transportation. Surface parking has been relocated away from the central campus to encourage use of alternative transportation. Transportation demand management programs include the New Directions Program, the Class Pass, bicycle programs, and short term parking limitations. The Class Pass and Bear Pass systems allow registered students and staff to ride free of charge on campus buses. Carpooling has increased among the faculty and staff due to reduced pricing of carpool parking permits. The University has electric charge stations for electric cars used by University staff and for commuting. Campus Biodiesel Committee formed by staff members, is currently researching the feasibility of implementing biodiesel conversion in some of Berkeley's campus service fleet vehicles (UCB Campus Sustainability Assessment, 2005).

The campus' bike system has been planned to coordinate with the City of Berkeley's extensive network of designated bike lanes and bike boulevards. Bicycle parking is provided throughout the campus (UCB Campus Landscape Master Plan, 2004). The UCB's goals are maintaining the current modal split, creating strategies to increase transit ridership or encourage cleaner fuel consumption, reducing parking rates for high-efficiency vehicles or alternative fuel vehicles, obtaining cleaner fuel contracts, implementing biodiesel conversion and improving the Bike Plan (UCB Campus Sustainability Assessment, 2005). The Figure 5.9 below shows campus pedestrian and bicycle routes in the UCB Campus Park.

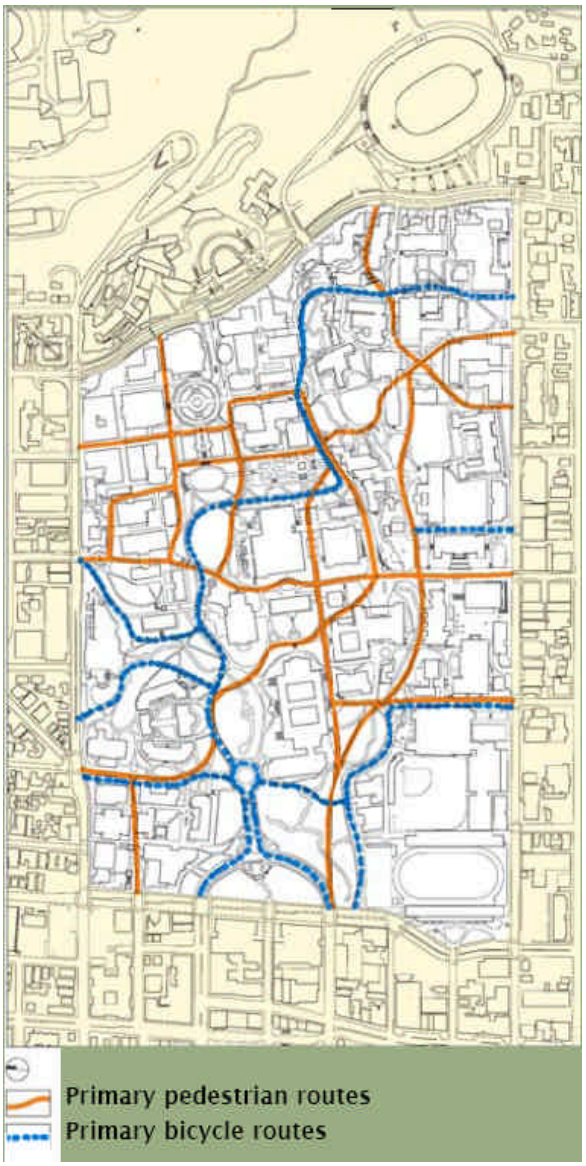

Figure 5.9: UCB Campus Pedestrian and Bicycle Routes (UCB Landscape Master Plan, 2004)

The UCB Campus contains Botanical Garden, Agricultural Experiment Station, Strawberry Canyon recreation and study area, an ecological study area and faunal refuge for educational purposes. The UCB Hill Campus and Campus Park serve as both an arboretum and an outdoor laboratory planted for research and classroom needs of the faculties. The Agricultural Experiment Station also supports the research and academic needs of the faculty. The Experiment Station planted various conifers and hardwood timber trees and many Australian species that still remain both on the Central Campus and in Strawberry Canyon. An Economic Garden established near the Centre Street entrance contains grasses, forage plants, cereals, medicinal and textile plants, vegetables and a variety of trees and shrubs studied by students in botany, pharmacy, and other disciplines (UCB Campus Landscape Heritage Plan, 2004). The Botanical Garden was established in the Campus Park in 1891, and moved to its present location in 1926. The garden is located on a 34 acre site, and Strawberry Creek flows through the southern section and is incorporated into the garden design. It provides a unique variety of microclimates that accommodate over 13,000 plant species and varieties, organized by geographic origin (UCB Campus LRDP 2020, 2005).

UCB Campus Sustainability Assessment involving students, faculty and staff is a great example for environmental stewardship success. UCB has also provided a role model of environmental education and stewardship through its program to restore Strawberry Creek. The university community uses the creek as an outdoor lab, and the design of new buildings incorporates features to protect water quality and improve the habitat. In 2005, Chancellor's Advisory Committee on Sustainability organized a walking tour of sustainable progress at UCB in order to promote environmental management and sustainable development throughout the community.

There is a wide range of campus student groups engaging with issues from waste management to green building design to environmental theme housing in the campus. The student Environmental Coalition (ECO), one of the students groups, has a goal of bringing together many environmental groups in campus in a coordinated fashion, developing a shared network, and providing an avenue by which students can be involved in environmental initiatives (ECO, 2005). Other environmental committees and groups are as follows;

- Chancellor's Advisory Committee on Sustainability formed in 2003
- University and Community Partnership Recognition
- Berkeley Alliance which is a non-profit partnership between UCB, the City of Berkeley, and the Berkeley Unified School District.
- Annual Green Gathering

UCB has a project of developing a Green Materials Guide clarifying green versions of materials, pricing and vendor contact information used in building and landscape construction. Establishing a current and updated list of sustainability-related courses, applying environmental literacy in the curriculum, creating an academic advisory committee, fostering additional interdisciplinary collaboration and providing better media coverage for sustainability weeks are the goals of UCB's sustainability policies (UCB Campus Sustainability Assessment, 2005).

5.1.3 Monitoring and Campus Planning

UCB has released several LRDP documents, in 1956, 1962, 1990, and most recently in 2005. The 2020 LRDP is UCB's land use and physical development plan. It integrates the design framework of New Century Plan and the academic principles articulated in the Strategic Academic Plan. "Sustainable Campus" section of the 2020 LRDP is devoted to the goals for developing UCB into a more sustainable campus (UCB, 2006).

In 2002, the Campus Planning Office developed the New Century Plan in association with Sasaki Associates (Figure 5.10). In 2003, the Campus Planning Office developed the Landscape Master Plan for UCB campus. The Plan presents a broad physical framework for the use and restoration of open spaces in the central campus. In 2004, the Landscape Heritage Plan was developed. This plan examines the key characteristics of the historic Classical Core of UCB Campus Park and provides guidance for further developments in a manner that respects its landscape heritage (UCB Campus Landscape Heritage Plan, 2004).

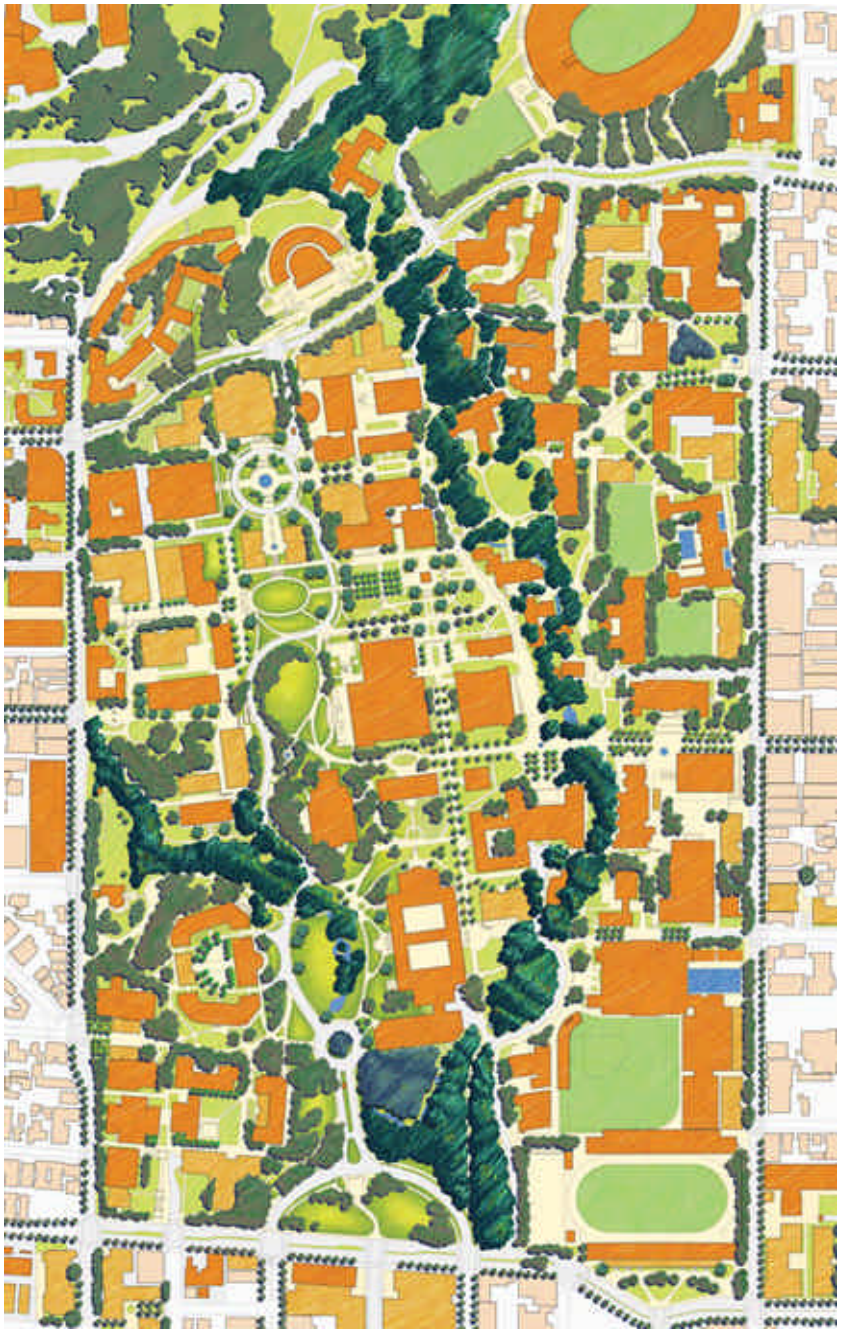

Figure 5.10: UCB New Century Plan, 2002

In 2005, UBC completed a sustainability assessment which was carried out throughout the campus. UCB Campus Sustainability Assessment is a comprehensive report prepared to define and measure the indicators of sustainability in the campus by using nine systems (Energy; Water; Built Environment; Transportation;

Purchasing & Waste; Land Use; Food; Health & Wellbeing; Academics & Culture) comprised of 32 indicators of sustainability. The report describes the performance, accomplishments, and also identifies potential opportunities for future projects. This assessment has been achieved by students, faculty and staff (UCB Campus Sustainability Assessment, 2005).

Currently, the University of California, Berkeley, has completed an Environmental Impact Report for the year 2020 as part of the LRDP. The LRDP declares a number of natural areas as off-limits for new constructions and describes a number of design plans for increasing green space in specific areas. The New Century Plan which started in 2002 provides a strategic plan which controls the University's capital investment program in relation to sustainable design goals. The UCB has a target to serve as a model for sustainable campus. The Central Campus is currently being renovated in accordance with the New Century Plan and the Landscape Master Plan (Figure 5.11). Many of the design initiatives in these plans include plans for removal of non-natives, diseased and dying plants, and filling gaps with native vegetation (UCB New Century Plan, 2002).

Figure 5.11: UCB Campus Park Landscape Plan Initiatives (UCB Landscape Master Plan, 2004)

5.2 University of Nottingham Jubilee Campus

> *"The Jubilee Campus extends an English tradition of elegantly-wrought pavilions within a romantic landscape, but also embraces an environmentally responsible architecture fit for the new millennium" (Fawcett,2000, p.42-46)*

The Jubilee Campus established in 1999 is the addition to Nottingham University, one of Britain's oldest universities. It is located about a mile away from the University of Nottingham's main University Park Campus. Jubilee Campus houses the University of Nottingham Business School, the School of Computer Science and Information Technology and the Faculty of Education. It was designed by Sir Michael Hopkins and won the 2000 BCIA award for 'Building of the Year' and the 2001 RIBA Journal Sustainability Award. Jubilee Campus has been transformed from a brownfield, which is an over-used industrial area containing a bicycle factory, to a University campus. Like the University of Nottingham's Park Campus, the campus has been developed around a lake containing plenty of green space. The campus also contains many innovative and environmentally sensitive elements such as grass roofs and solar panels (University of Nottingham, 2006).

5.2.1 Jubilee Campus Profile

The Jubilee Campus was designed and constructed with the goals of low-energy, low maintenance, nature conservation and wildlife creation. "The Jubilee Campus is a milestone in green architecture, pioneering an innovative combination of mechanical and wind-driven ventilation, while also bringing together many other green strategies. The campus's landscaping is an intrinsic part of its environmental system. Even, it extends onto the roofs to improve insulation and prevents of reflected heat increase" (Carr, 2001, p.10).

The campus comprises of eight buildings including three faculty buildings, central teaching block, a learning research centre, an accommodation block, undergraduate halls and a restaurant (Figure 5.12).

Figure 5.12: Jubilee Campus general view (Hopkins Architecture, 2005)

The campus buildings were arranged along the edge of an artificial lake connecting University Park visually. The majority of roofs incorporate both 'green roof' technology and photovoltaic panels. These panels produce enough energy for the ventilation of the buildings. The photovoltaic panels not only provide a clean source of energy that can meet the yearly requirement of the ventilation but also provide the central atria with shade. The woodland area on the south east screens the residential area (Sustainable Developer Guide for Nottinghamshire, 2005).

The main faculty buildings located around a lake are similar in form, each consisting of three wings connected either by full-height sloping glazed atria or landscaped open courtyards (Figure 5.13).Vertical circulation within the faculties is provided at the back by circular stair towers (CABE, 2006). The library, the Sir Harry and Lady Djanogly Learning Resource Centre located in the middle of the lake, is the main feature of the campus. The building visually floats on the lake providing a focal point for the whole of the Campus (Figure 5.14).

Figure 5.13: Jubilee Campus buildings and the lake (Battlemccarthy, 2006)

Figure 5.14: The library, the Sir Harry and Lady Djanogly Learning Resource Centre in Jubilee Campus

5.2.2 Green Design Applications

The development of the Nottingham University Jubilee campus shows a wide range of green design applications. The project succeeded the transformation of a brownfield factory site, into a newly developed university campus. Environmental strategies for building design and ecological strategies for campus landscape have been established during the campus planning process of Jubilee Campus (see Appendix A).

The following section gives the details of green design initiatives and accomplishments related to landscape design. Current green design applications and goals for campus landscape in the University of Nottingham Jubilee Campus are summarized in Table 5.2.

Table 5.2: Green Design Applications in the University of Nottingham Jubilee Campus

Criteria	Green Design Applications
Energy Conservation	Solar panels
	Monitoring energy usage
	Wind-catchers for ventilation and heating
	Cooling effect of the lake
	Building form and orientation considered for energy conservation
	Use of passive solar energy
	Natural lighting
	Light sensors
	Planting for shading
Waste Management	Recycling
	Rainwater collected in the lake
	Using existing soil for the landforms
Use of Sustainable Landscape Materials	Use of recycled materials such as warmcell insulation
	Use of wood from sustainable forests
	Use of excavation materials from the former site building
	Use of demolition materials
Water Management	A 0.5 hectare artificial lake
	The lake harvests rainfall
	Native and non-invasive wetland plants
	Aquatic planting and a compressed-air aeration
	Green roofs
	Reed beds
	Open ditches

Table 5.2 continues.

Criteria	Green Design Applications
Wildlife/Habitat Conservation	Brownfield restoration
	The lake and the belt of mature trees
	Green roofs
	Preservation of diversity in the existing woodland
Landscape Maintenance	Native planting
	Non-invasive plants
Transportation and Parking	Car parking at the campus entrances
	Pedestrianization
	Bicycle parking
Educational Gardens	Courtyards
	Campus landscape
Environmental Stewardship	Conferences, meetings
	Curriculum
	Student organizations

The reduction of CO_2 emissions is a key part of the UK's commitment to reduce the amount of carbon dioxide released into the atmosphere under the Kyoto Protocol. The Jubilee Campus has been designed to reduce CO_2 emissions by 75% and reduce the consumption of power for a building of its size by half (McCarthy, 2005).

Building form and organization are carefully considered in the Jubilee Campus. Narrow buildings facing east-west and glazed atriums oriented south-west provide efficient ventilation, heating and cooling. Additionally, the atriums and courtyards act as buffer spaces. The faculty buildings, facing south-west onto the lake, take advantage of the prevailing winds and optimizing passive solar lighting (Figure 5.15). These buildings are restricted to three floors, to optimize daylight to the spaces in and around buildings and to encourage the use of stairs, rather than lifts (Berry and Thornton, 2004).

The faculty buildings are mechanically ventilated and heated by using a low-pressure drop system which is more energy efficient than natural ventilation. Air enters the air-handling units, which work with thermal wheels and indirect gas (Figure 5.16). The fans function by the use of the photovoltaic cells. Used air leaves via the stairwell and the corridors and eventually returns to the specially designed air-handling units for heat regain (ARUP, 2006).

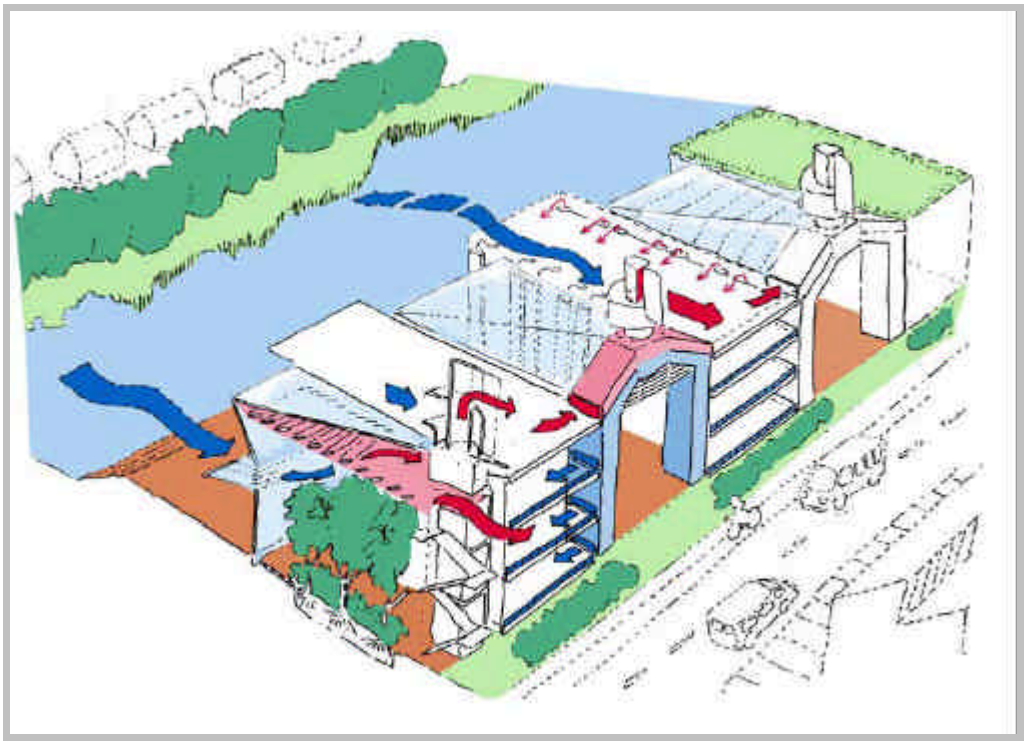

Figure 5.15: Air movement in Jubilee Campus buildings (Hopkins Architecture, 2005)

Figure 5.16: Wind catchers-air handling units on the roofs of Jubilee Campus faculty buildings (Hopkins Architecture, 2005)

312 photovoltaic cells placed in the glazed atrium roof and connected to the ventilation and cooling systems (Figure 5.17). These cells also provide shade for the atriums inside the building. The form of a thermal mass of exposed concrete by using thermal wheels to provide heat exchange within the buildings is also another design technique for sustainable energy source (ARUP, 2006).

Figure 5.17: Photovoltaic cells on the roofs of Jubilee Campus buildings

Campus buildings were located in order to catch natural lighting. Light sensors were installed to reduce energy consumption. These light sensors, activated by people presence, switch lights on or turn them off in relation to daylight levels throughout the campus. Other energy conservation accomplishments are cooling effect of the lake by evaporation; planting trees near buildings and pathways to provide shade; and usage of the excavated lake material to form screening and earthworks.

The university is committed to using products from renewable sources and to recycling waste. This policy was implemented during the construction process of the campus by using cedar redwood cladding with its recycled newspaper insulation and creating the lake and landforms from existing soil on the site (Berry and Thornton, 2004). Rainwater is collected in the lake to provide the recycling of rainwater from parking lots and building run-offs.

In order to achieve the University's commitment to use renewable products and to recycle waste, the landscape was designed to retain excavation materials from the

former site building. Planting schemes are chosen for their ability to survive on these materials to minimise the need for imported materials like topsoil (CABE, 2006). Existing resources were retained in the campus. For instance, spoiled and demolished materials were used to shape the landscape. By grading and mixing the various materials on site, a low nutrient status of the material was provided. This was used as a lake base and as a sub-soil on top of the landforms. In total, approximately 4500 m3 of excavated material was recycled within the landscape (Battlemccarthy, 2006).

Construction materials were carefully chosen in order to avoid the use of high energy dependent or environmentally harmful materials. Warmcell insulation, a substance made from recyclable paper, was used in the walls of some buildings. The wood used for the cedar cladding of the faculty buildings was from sustainable forests in Canada and was the most inexpensive available (ARUP, 2006).

A 0.5 hectare lake (Figure 5.18) harvests rainfall from surrounding buildings, roads and car parks whilst providing free cooling effect to surrounding environment. Water quality in the lake is maintained by using the combination of mechanical and natural systems. The systems include substantial areas of floating, submerged and marginal oxygenating aquatic planting and a compressed-air ventilation system. Characteristic, native and non-invasive wetland plants of the Nottingham area were used for the lake and surroundings (Battlemccarthy, 2006).

Figure 5.18: A view of the Jubilee Campus, including the Learning Resource Centre (NUMBA, 2005)

The large surface area of the roofs and roads provide significant amount of rainwater run off. This was collected, stored and cleaned by reed beds on site in the lake and open ditches. The ditches were designed to fluctuate in size in order to accommodate stormwater. The lake has ecological, recreational and aesthetic values for the campus community. It provides cooling effects for the campus buildings and landscape in the summer. In addition, the lake divides the university buildings from the residential area.

The university set ambitious goals for environmental management, including promoting new habitats for wildlife and ecology, while preserving the diversity in the existing woodlands. The lake, green roofs and the belt of mature trees at the boundary with the adjacent houses make significant contributions to the wildlife habitat. The linear existing woodland has been increased by planting new local trees to provide wildlife (Berry and Thornton, 2004). Using native and non-invasive plants, creating wildlife around the lake and greenroofs result with low maintenance on the Jubilee Campus.

Green roofs planted with moss and lichen to provide a habitable environment for a wide range of birds and insects. Maintenance-free roof plantings provide thermal mass, which can stabilise inside temperatures and regulate solar radiation (Figure 5.19). Structurally, the green roofs are not heavier than conventional roofs (Palmer, 1999).

Figure 5.19: Greenroof on the roof of Jubilee Campus buildings

The site for the campus previously contained industries including coal mining, a waste destruction facility, a tractor depot and the Raleigh factory. Therefore a serious restoration work was undertaken to create a natural open space. Tests were carried out to check on the levels of contaminants in the site. The design of the campus was determined in an effort to avoid the pollutants existing before and to create a sustainable campus (ARUP, 2006).

The Jubilee Campus is within easy walking distance of the main campus and well served by public transport. Car parking is provided at the campus entrances to minimise traffic disturbance. Pedestrian paths were segregated from vehicle traffic. There are pedestrian ways that benefit from cooling effect of the lake and shading provided by the buildings (Figure 5.20).

Figure 5.20: Pedestrian paths under the buildings in Jubilee Campus

A promenade connects the faculty buildings for pedestrians and cyclists whilst vehicles are restricted to the eastern side of the campus. The promenade is linked to the City Cycle way and a bus connects the new and old campuses. There are sufficient amount of bicycle parking places for cyclists in the campus (Hopkins Architects, 2005).

Figure 5.21: A view of the Business School across the lake in the Jubilee Campus (NUMBA, 2005)

Figure 5.22: The Exchange Building and biycle parks in the Jubilee Campus

The courtyards between the buildings create both a recreational area and an outdoor classroom for the University (Figure 5.23).

Figure 5.23: One of the courtyards in Jubilee Campus

Jubilee Campus, with its innovative environmental friendly design, provides a good educational area for the university community. The area was once contaminated by heavily polluting industries and now it contains a green campus with extensive planting and landscaping and a lake encouraging wildlife back to the area. This site history can provide a good environmental awareness and educational environment.

In 2004, a conference related to green marketing, and eco-labelling was held in Jubilee Campus. In 2005 Nottingham University Business School was named as one of the world's top 30 providers of innovative, full-time MBA programmes and faculties that lead the way in integrating issues of social and environmental stewardship into business school curricula and research (University of Nottingham, 2006).

5.2.3 Monitoring and Campus Planning

During the construction of Jubilee Campus many tests were carried out to check the levels of contaminants on brownfields. Physio-chemical analysis of excavated soil was carried out to identify the presence of phytotoxic and zootoxic compounds and determine the nutrient status of the material used on the site (Battlemccarthy, 2006).

The University of Nottingham monitored the buildings for one year after their completion. The faculty Management have been monitoring the energy usage to achieve proposed targets. The University Department of Built Environment have been monitoring photo-voltaic outputs (Hopkins Architects, 2005).

In 1999, first master plan for Jubilee Campus designed by Hopkins Architect and Battlemccarthy was responsible for campus landscape (Figure 5.24). Arup were appointed as structural, mechanical, electrical, building services and civil engineers, for the project.

Figure 5.24: Jubilee Campus Landscape Plan (Battlemccarthy, 2006)

Further expansion of the Jubilee Campus towards 2015 is proposed by the University of Nottingham, based on a Master plan prepared by Michael Hopkins and Partners. Nottingham City Council providing the adjacent land for University use, in order to allow the campus to grow over 100 acres. In 2006, the development of a Research

and Innovation Park is planned. In addition, "volcano-like" building as a landmark for the campus, new academic buildings, and halls of residence will be built. Campus location plan is shown in Figure 5.25.

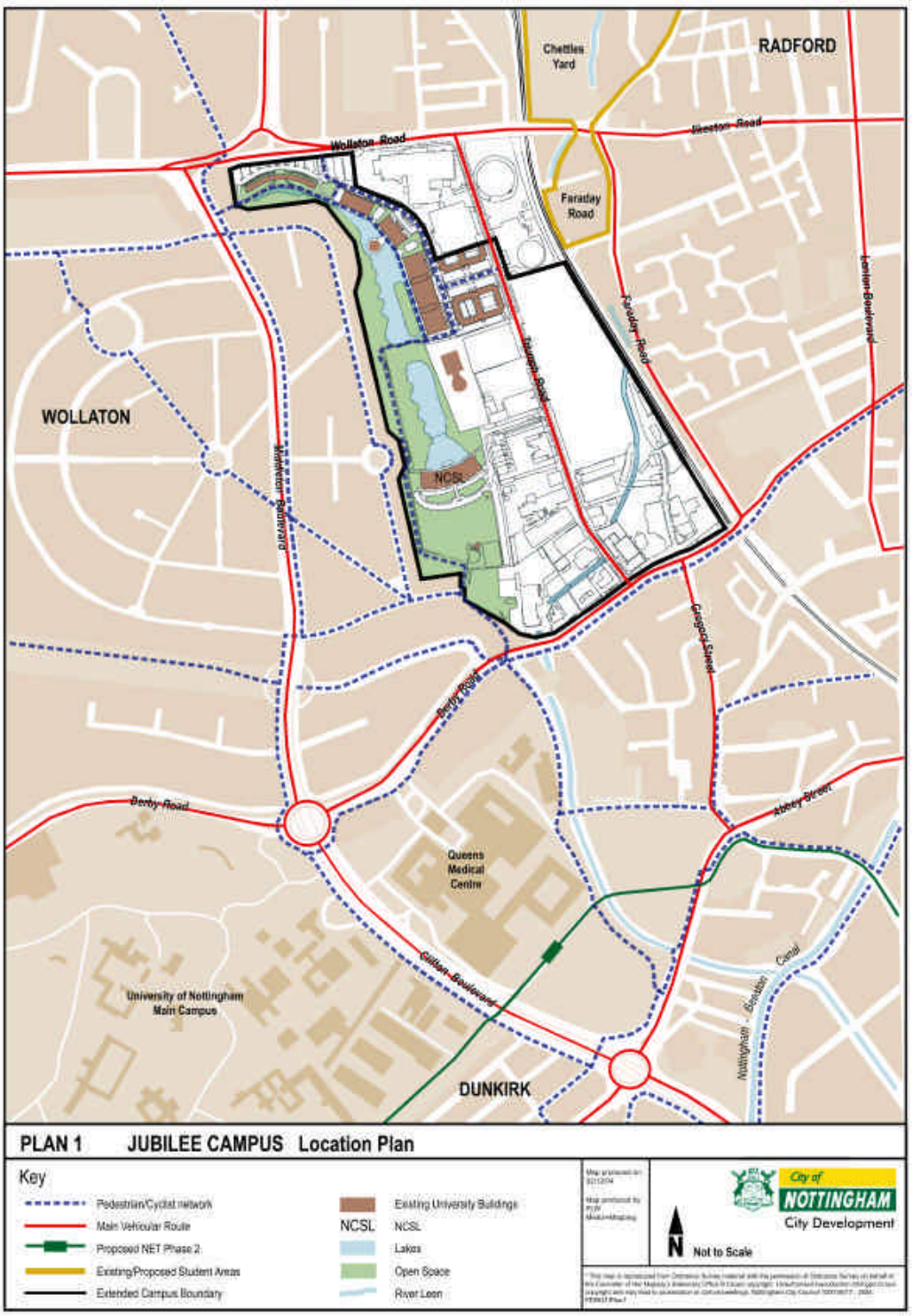

Figure 5.25: Jubilee Campus Location Plan (Nottingham City Council, 2004)

The land use strategy for further developments is illustrated in Figure 5.26. According to Jubilee Campus Development Brief (2004), the details of land use strategies are as follows;

- Student Residential Zone: Further student accommodation and facilities are considered at the northern end of Triumph Road, which will comprise a 'Student Village'.
- Academic Expansion Zone: Land west of Triumph Road is reserved for growth of the University's academic functions, expansion of the National Centre for School Leadership or for other teaching based institutions.
- Research and Innovation Park: Accommodation for knowledge based industries will be provided on the east of Triumph Road and north of the River Leen.
- Mixed Use Zone: Land on the south of the River Leen and east of Triumph Road is allocated for mixed uses. These uses must be compatible with the objective of creating a high quality centre of learning and employment.

Specific guidelines for further developments are illustrated in Figure 5.27. According to Jubilee Campus Development Brief (2004), generic principles are summarized below:

- Large open car parking areas will not be allowed and parking on Triumph Road will be limited. Where possible, underground parking will be constructed.
- Variation in building heights and densities will be encouraged, but structures of more than 3 floors should be positioned fronting the main through routes. There is opportunity for higher buildings at the main Academic Quarter - Innovation Park intersection.
- Opportunities should be improved to open up, emphasize and frame key views into and across the campus particularly from Wollaton Road, Derby Road and Triumph Road.

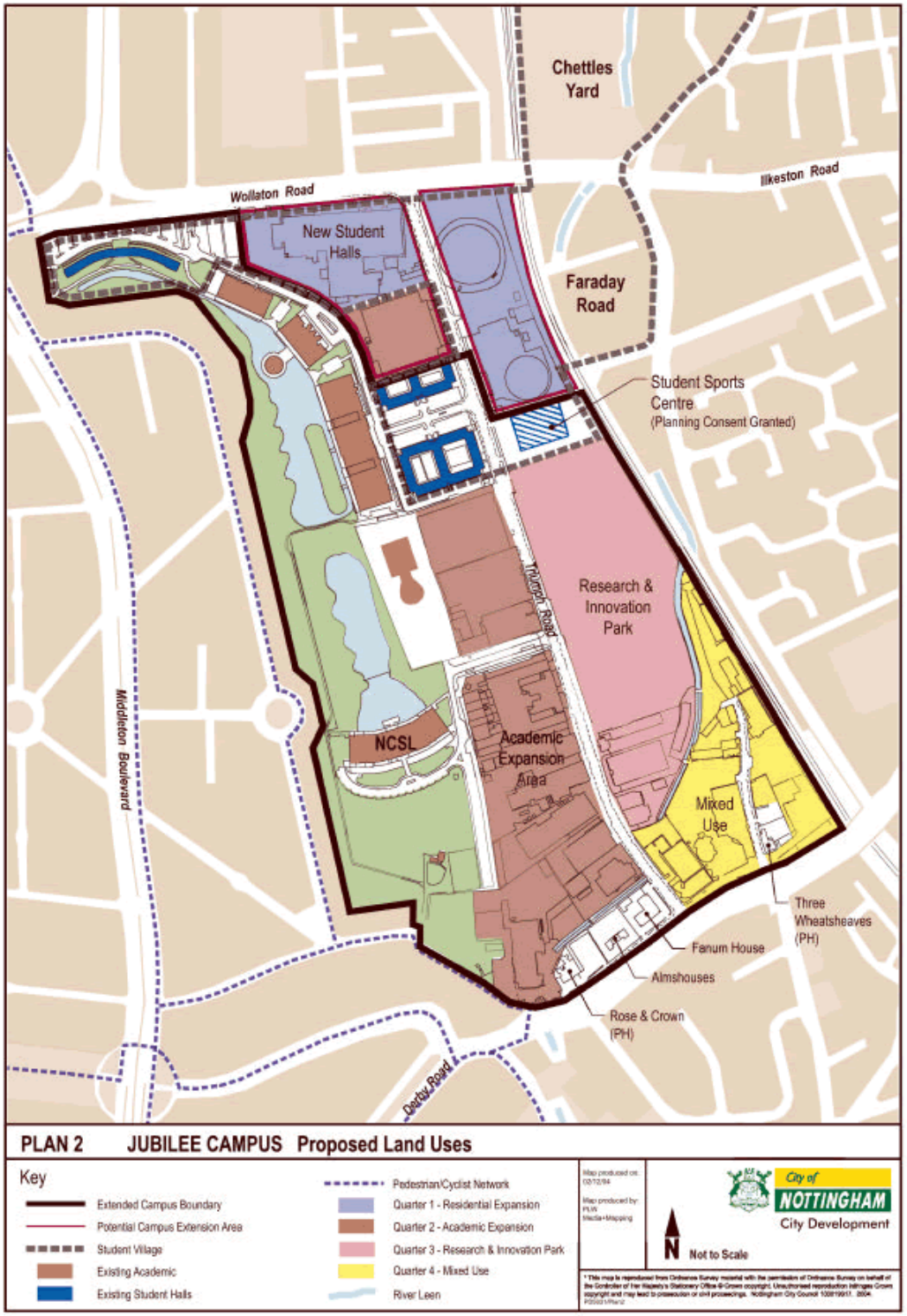

Figure 5.26: Jubilee Campus Proposed Land Uses (Nottingham City Council, 2004)

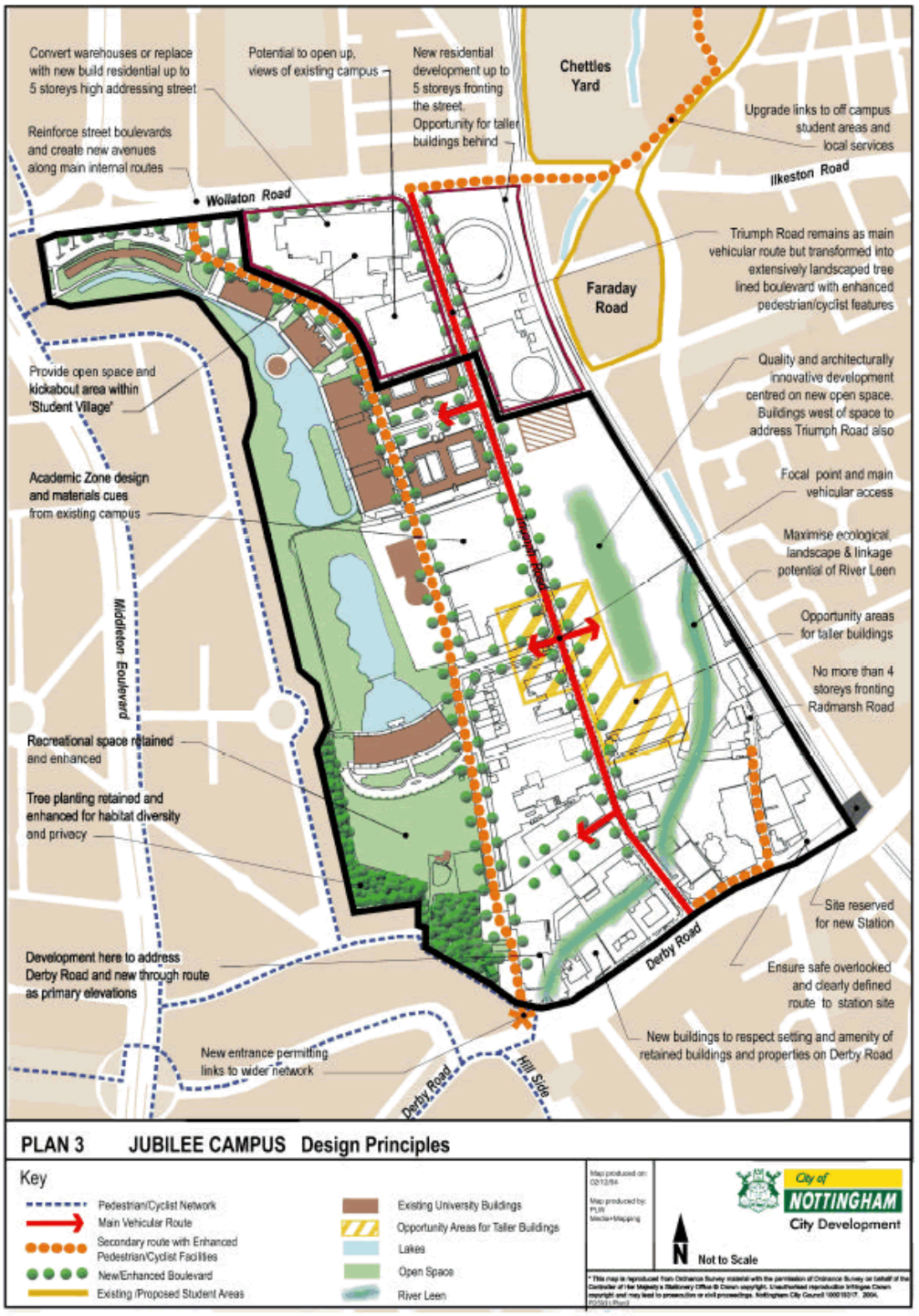

Figure 5.27: Jubilee Campus Design Principles (Nottingham City Council, 2004)

CHAPTER 6. A PROPOSAL OF CONCEPTUAL GREEN DESIGN MODEL FOR LANDSCAPE PLANNING IN UNIVERSITY CAMPUSES

Today's university campuses mostly contain wide areas with several facilities representing as a microcosm of a larger community. University campus planning has to cover the environmental and social factors that affect cities in order to obtain a sustainable environment. Besides being an education institute, campuses also form examples for other developments in their cities they are located in. Green design applications for a sustainable campus do not only have positive impacts on university students, staff and faculty, they also affect the communities. In this manner, campus provides opportunities for campus users and whole community in order to observe campus as a model, and understand environmental concerns and implement green design while involving in campus planning.

Every campus is unique with its natural, social and economic resources and planning history. First of all, location, size of campus, land use, site topography and micro-climate are the main physical factors that should be considered during campus planning. These factors should be assessed in an effort to benefit from nature and conserve the resources of the site. In this part, general green design ideas that can be implemented in most campus landscapes across the world are explained. These ideas can be interpreted according to the conditions of the campus and can be developed with general guidelines given throughout this part.

Sustainable campus efforts and green design initiatives give institutions of higher education an opportunity to use the campus to teach, showcase progressive principles, and serve as a model for the community at large. The campus must be viewed as a tool for preventing environmental problems, and for restoring and improving the environment. The manner in which it carries out its daily activities is an important demonstration of the ways to achieve environmental awareness in the whole community. A sustainable campus should understand and respect the natural systems that comprise the landscape. Campus landscape is an important part of most

university campuses and communities. It is more than aesthetics; it also expresses values and awareness.

Creating a sustainable campus landscape not only helps in educating people but also provides opportunities for community involvement in the planning process. Since students, faculty, staff and members of the surrounding communities have an interest in and an impact on the campus landscape, they need to be engaged in the planning process. Responsibility for the monitoring sustainable development must be shared and integrated throughout the campus. In order to develop campus plans, planning and design teams, professionals in engineering, cost-assessment, construction, building operation and maintenance are needed.

6.1 Proposal of a Campus Planning Method with Green Design Approach for a Sustainable Development

There should be more comprehensive, environmental friendly plans supporting green design initiatives rather than traditional campus plans in order to achieve sustainability in campuses. There are many components of greening a campus from changing the curriculum to undertaking a campus environmental assessment. A green design campus planning for a sustainable development process including these components can be categorized into 4 phases which are summarized in Figure 6.1.

The first phase is requirements and analysis phase. It includes site surveys, analysis, setting targets and budgets, scheduling, and establishing policies and design guidelines. Firstly, a higher education institution should state its mission by specifying goals and objectives for sustainability. Then, site selection, site surveys and analysis have to be addressed. Policies and design guidelines to help to achieve these goals and objectives of campus development should be composed.

Design and planning phase follows the first phase. In this phase campus plans should be developed. The development of a sustainable campus landscape requires master plans, long range development plans and environmental plans. Campus Landscape Master Plans and Long Range Development Plans are very important in the campus landscape planning process. These plans can be supported by landscape heritage

plans, mitigation plans, waterscape plans, land use plans, habitat plans, transportation plans, etc.

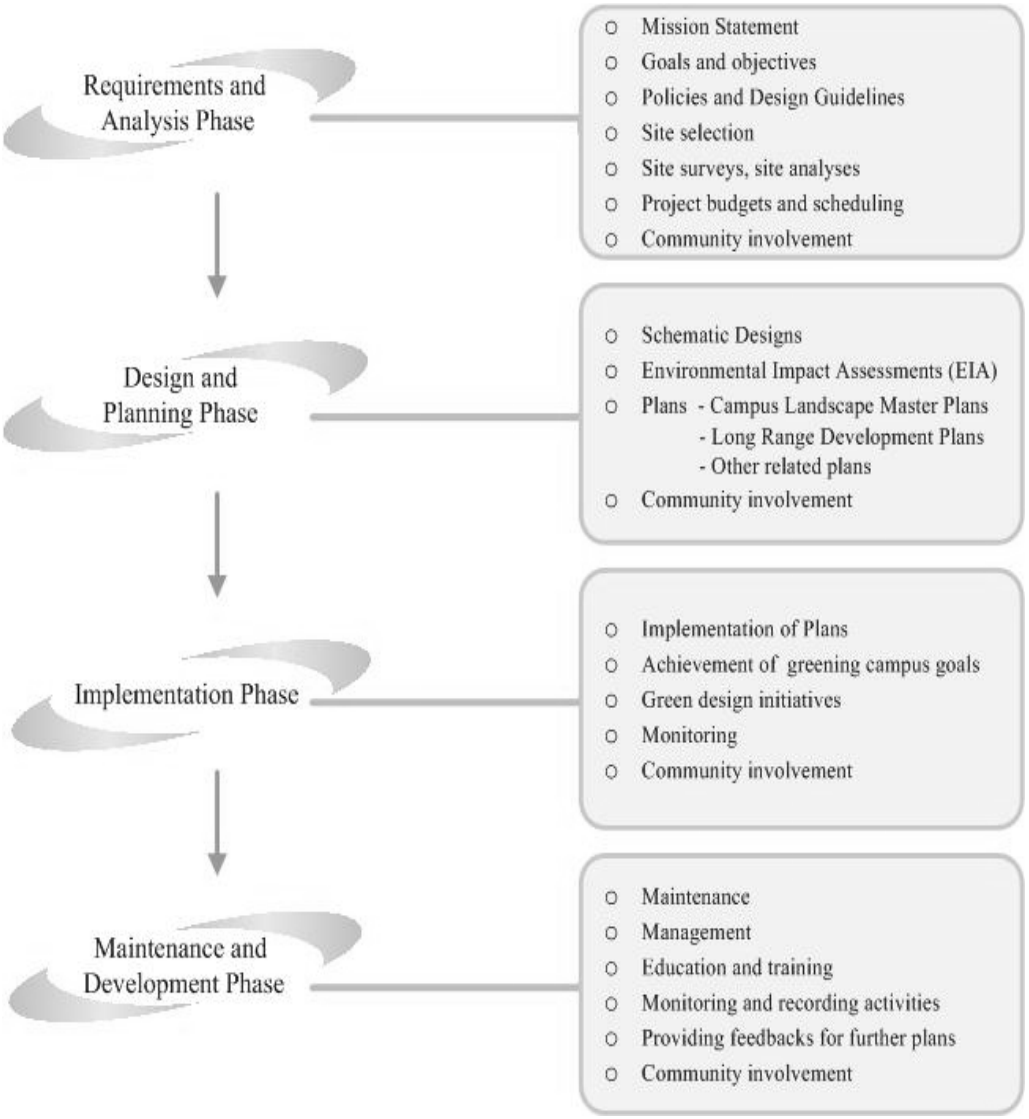

Figure 6.1: Proposed Campus Planning Method for Sustainable Development

The higher education institution should find out how much impact its campus already has and will do in the future relating with the environment through Environmental Impact Assessments (EIA). Most higher education institutions use large tracts of land and consume significant amount of natural resources, so they have huge impacts on the environment. These possible impacts can be assessed before and after the construction of the campus site by EIA and other sustainability assessment frameworks. Subsequently, the implementation phase takes place following the

design and planning phase. During this phase, green design initiatives implemented by the help of environmental stewardship play an important role in achieving a green agenda in the campus.

The last phase is the maintenance and development phase which will be ongoing throughout the university's existence. To overcome problems and deficiencies, and to sustain the effects of the campus plans during this phase, landscape maintenance and management plans should be generated and activities should be recorded regularly. Additionally, these initiatives should be supported by providing education and training throughout the campus.

Monitoring the existing situation after the implementation should be done regularly to understand how the campus achieves its sustainability goals. For monitoring purposes, different kinds of assessment frameworks such as campus sustainability assessments can be employed. Groups formed by the university community to monitor the activities of the campus can generate a baseline to determine further policies and plans. Evaluating the success of the green design initiatives by monitoring gives the opportunity to redefine the planning process. Accordingly, new and more efficient strategies and plans can be implemented for further developments in order to achieve sustainability. Community involvement should also be a part of all phases in order to promote environmental awareness and to spread environmental stewardship.

6.2 Proposed Green Design Guidelines

Green design criteria defined in this study have been evaluated and examples from different university campuses across the world have been reviewed in the previous chapters. In this part, the general framework of green design applications has been clarified and guidelines for these applications have been developed in order to achieve sustainability goals in university campus landscapes. Green design criteria have been examined under two categories including social and physical dimensions. Each criterion comprises green design practices applicable in campus landscapes. For instance, topography and land use, building orientation, vegetation, greenroofs, water, energy-efficient lighting, and renewable energies are important tools and

subjects for energy conservation. The details for other green design criteria can be seen in Table 6.1. This table gives the general framework of green design concept in campus landscapes.

Table 6.1: The physical and social dimensions of green design applications

Criteria		Green Design Applications
Physical	**Energy Conservation**	Topography-land use, building orientation, vegetation, greenroofs, water, energy-efficient landscape lighting, renewable energy
	Waste Management	Waste reduction, recycling, composting, on-site waste wastewater treatment, grey water collection
	Use of Sustainable Landscape Materials	Soft landscape materials and hard landscape materials, material selection, environmental labelling
	Water Management	Water conservation, xeriscaping, native planting, irrigation, wetlands and sormwater basins, daylighting, rainwater harvesting, drainage
	Wildlife Habitat Preservation	Preservation of natural resources, native planting, habitat corridors, creating habitat for wildlife
	Pest Management	Cultural controls, mechanical controls, biological controls, chemical controls
	Landscape Maintenance	Mowing, trimming, and weeding, irrigation, diagnosis and treatment, pest management, using fertilizers and compost, pruning, hard landscape maintenance, equipment use
	Transportation and Parking	Using renewable fuels, public transportation, parking areas, bicycle routes, pedestrian routes
Social	**Educational Gardens**	Outdoor classrooms, laboratories, theme gardens, demonstration gardens, botanical gardens and arboretums
	Environmental Stewardship	Educational reforms, mission statements, student projects, surveys, questionnaires, auditing, internships, groups, unions, stewardship programmes, media.
	Monitoring and Sustainability Assessment	Campus sustainability assessments, environmental impact assessments, determining indicators

The conceptual model for campus landscapes in this study has been formed as a result of assessments of green design approaches and initiatives in different university campuses throughout the world. In some university campuses there are green design initiatives including green building, water and energy conservation, waste management, transportation, pest management, wildlife conservation, landscape maintenance, monitoring. Some of these green design initiatives related to campus landscape have been examined throughout the study. However, not a single campus includes all possible initiatives for campus greening. For this reason a comprehensive guideline that shows what can be done for creating a sustainable campus landscape has been developed. The guidelines focus on activities and practices for greening a campus in terms of achieving sustainability in campus landscape. For instance, green design actions for energy conservation such as

orienting and organizing buildings provide natural ventilation, cooling and good heating in the winter while they maximise natural lighting. The following tables cover each physical green design criteria comprehensively (Table 6.2-6.9).

Table 6.2: Guidelines for Energy Conservation

Objectives	Actions
To provide natural ventilation and cooling	Locate buildings to best utilize the local microclimate
	Provide a cooling effect by designing water bodies
To provide good heating in winter	Orient and organize buildings
	Minimise facades prone to cooling and wind chill
To block the sun in summer	Orient and organize buildings
	Plant trees or climbing plants to cover south facades providing protection from summer sun when it is needed
	Use trees to provide shading
To maximize natural lighting	Orient buildings and use windows
To block unwanted wind, pollution, noise and solar radiation	Create landforms
	Use windbreaks or shelterbelts
	Use evergreen plants like conifers to form a barrier to block winter winds
To reduce energy consumption	Screen outdoor air conditioning equipment with plantings
	Use green roofs to minimize the energy loss by insulating the buildings in winter and reducing air conditioning needed in summer
	Use solar powered lighting features and low voltage lights
	Use light level sensors and movement sensitive lights to switch light on and off at appropriate times
	Promote minimal energy use and avoid energy losses by using meters, signs, posters and other available media opportunities to instruct the campus community.
To prevent pollution	Use renewable energy sources such as solar, wind, water, biomass and geothermal energy
	Reduce energy consumption
To reduce temperatures	Use turf and groundcover plants between buildings and paved areas such as driveways and sidewalks
	Minimize the use of heat absorbent and reflective materials or shade them from any direct sun in hot climates
To use energy resources efficiently	Create on-site renewable-energy plants such as wind farms, biomass plants and hydroelectric centrals if available
	Use passive solar energy, solar water heating and photovoltaic energy
	Use solar panels on the roofs of buildings to convert solar radiation into electricity
	Generate heating and electricity from biomass (grasses, trees, wood-waste, chips and other biological materials) where this fuel is available
	Be aware of technical innovations aiming at the reduction of energy use and new applications
	Look for alternative sources of energy such as hydropower and geothermal energy locally

Table 6.3: Guidelines for Waste Management

Objectives	Actions
To reduce waste generation	Recycle and reuse
	Include a campus wide recycling facility
	Recycle by recovering and reprocessing usable products that might otherwise be disposed of
	Recycle materials, ranging from cans, glass, cardboard, paper, food, yard trimmings and construction materials to laboratory chemicals
	Purchase sustainable materials, environmental friendly products
	Include a site waste management program
To reduce construction, operations, and maintenance costs	Provide on-site wastewater treatment systems and composting facilities
To encourage recycling, reuse and purchasing	Arrange accessible, attractive and safe places for recycling and waste collection
	Plan proper locations for waste and recycling bins and connect them with the main planned functions
	Promote recycling, reuse and purchasing by using media, meetings, courses, etc.
To reuse and manage wastewater	Send grey water from bathroom sinks, baths and showers to treatment plants
	Send wastewater from other uses (e.g.: toilet flushing) to the sewer and to be cleaned before draining in the natural environment
	Use grey water on ornamental plants and lawns, or to irrigate trees, but not for vegetable gardens
	Collect rainwater to reuse
To improve the quality of landscape materials and to lessen landfill impacts	Build a composting facility where feasible
	Use compost products
To prevent pollution	Consider the possibility of recovering energy from biogas
	Lessen waste that goes to landfills
To conserve resources	Generate district heating from industrial or wood waste
	Provide on-site wastewater treatment systems
	Use recycled materials in landscape design and construction
	Design wastewater gardens where micro organisms convert chemical constituents of wastewater into nutrients for plant growth by a subsurface distribution system
	Use excavation and demolition materials from the site

Table 6.4: Guidelines for the Use of Materials for Sustainable Landscape

Objectives	Actions
To control pollution and erosion, preserve wildlife, conserve energy and water	Extend the use of plants
	Identify areas where recycled material can be used
	Use materials with low environmental impact during their life cycle
To maintain easily	Choose durable, easy-maintained recyclable materials
To reuse and recycle	Reuse existing soil, buildings and structures
	Use landscape construction products made from recycled materials
	Use reclaimed stone or brick, secondary aggregates, recovered soils and organic composts or street furniture manufactured from recycled materials
	Use locally manufactured materials instead of imported materials
To avoid runoff increase and to protect water quality	Use permeable materials
	Use plant material as much as possible
To encourage people to use materials with low environmental impact	Consider the use of materials which can be re-used and recycled at the design stage
	Promote the use of natural and ecological building materials
	Promote the use of materials from certified renewable sources
	Promote eco-labelling

Table 6.5: Guidelines for Water Management

Objectives	Actions
To conserve water	Provide shading near buildings to prevent water loss from nearby plants and soil
	Select plant materials based on soil conditions, water requirements, and the size of the site
	Create heat barriers by planting vines and shrubs
	Reduce areas of lawn, particularly in regions where lawns are not native and water usage is high
	Use efficient irrigation systems such as drip irrigation and sprinklers
	Use native plants that require minimal labour, watering, and fertilizer use
	Programme irrigation timers according to weather conditions manually or by using rain sensors
	Use zoning technique for irrigation systems to prevent excessive use of water
	Water plants at early hours of the day or at night
	Use recycled waste water for landscape irrigation
To control and collect runoff water	Design a lake or pond to help to collect runoff water
	Adopt greenroofs, wells, ponds and cisterns for the re-use of rainwater as non-drinking water
	Use permeable materials to cover paths, pedestrian areas and private streets wherever possible
	Design the site in such a way as to direct runoff from impervious surfaces (roofs or paved areas) to pervious areas (lawns, landscape, etc.)
	Use green roofs in rainy areas to absorb rainwater
	Open culverted waterways (daylighting projects help to slow and infiltrate runoff)

Table 6.5 continues.

Objectives	Actions
To prevent water pollution	Encourage waterside vegetation and the use of reed beds to absorb pollutants and to regularise increased runoff
	Protect ground wells, water reserves and watercourses against drying out and pollution
	Use sustainable drainage systems
	Separate stormwater and sanitary sewer systems
To conserve habitat and wildlife	Restore streams and rivers to their natural courses and character, carrying out any essential maintenance with as little intrusion as possible
	Promote daylighting projects that help the growth of aquatic and riparian vegetation
	Preserve and use natural drainage systems wherever possible
	Refurbish and enhance the banks of ponds and basins, rivers, wetlands

Table 6.6: Guidelines for Wildlife Habitat Preservation

Objectives	Actions
To preserve, restore and rehabilitate wildlife habitat	Define the density of a campus area, taking into account the carrying capacity of the environment and scarcity of land
	Protect natural resources and habitat while locating and planning new developments
	Provide buffers between natural areas and development areas
	Avoid soil excavation and earth-moving activities as much as possible
	Use excavated soil for new developments
	Provide ecological connections and natural passages between the campus area and adjacent sites encouraging the settlement of small animals and birds by avoiding barriers
	Protect and maintain trees and other vegetation which influence the bio-diversity and the microclimate
	Renovate and re-use existing buildings to protect the natural ecosystem
	Take care of existing historical elements when planning new functions and try to maintain old buildings
	Preserve highly fertile land for agriculture, forestry and educational gardens
	Restore landscape patterns such as old roads, paths, water flows and areas of ecological value
To provide habitat for wildlife	Identify ecological potential and landscape to create an attractive and varied living environment by incorporating valuable elements into the design process
	Use native plants to preserve the balance and beauty of natural ecosystems and to encourage wildlife species that accustom native plant communities as their habitat
	Provide specific habitat resources and ecological needs particularly for threatened species
	Reuse and revitalise contaminated and under-used land
	Restore brownfields such as vacant de-industrialised areas, former military sites, and derelict land for landscape use
	Restore and enrich soil and sub-soil by greening non-built up areas
	Create ponds and lakes for wildlife
	Provide space for new trees to grow, considering the space required for roots to develop underground
	Provide green inner courtyards
	Encourage use of green roofs

Table 6.6 continues.

Objectives	Actions
To create and connect habitat corridors	Utilize drainage ways, water channels, wetland areas
	Provide ecological connections and natural passages between the campus area and adjacent sites encouraging the settlement of small animals and birds by avoiding barriers
	Provide basins for rainwater with low banks for a better accessibility of animals and to allow plants to grow
	Use vegetation and control weeds and feral animals
	Retain buffers along wetlands, erosion prone slopes, and other fragile areas of special ecological importance

Table 6.7: Guidelines for Pest Management

Objectives	Actions
To mitigate negative impacts coming from pests to human beings	Implement Integrated Pest Management (IPM)
	Decide control actions such as cultural, mechanical, biological and chemical controls suitable to prevent unacceptable damage to ecosystem
	Reduce the pesticide use
	Use natural, organic fertilizers wherever possible
	Use biological, cultural controls
To preserve a healthy environment	Examine and record the health of plants regularly
	Track pests by identifying pest sources, nest locations and feeding areas
	Track temperatures and climate indicators to predict pest insect developmental stages and emergence
	Remove plant parts and debris (prune, gather, burn) that can serve as protective or over-wintering sites for many pests
	Avoid over-fertilization
	Use non-invasive plants
	Move weeds, especially before they produce seeds
To decrease reliance on pesticides	Use plants to attract naturally occurring parasites and predators that can control pests
	Select insect and disease resistant species and cultivars of plants
	Provide proper pest identification

Table 6.8: Guidelines for Landscape Maintenance

Objectives	Actions
To keep landscape healthy	Control and remove invasive plants
	Use mechanical methods of vegetation removal rather than applying herbicides
	Perform mowing at optimal times
	Remove weeds by hand-pulling where practical
	Prune plants carefully and regularly
	Utilize a comprehensive management system that incorporates integrated pest management (IPM) techniques
	Remove the plant material in cases where microscopic parasites, such as bacteria and fungi are causing damage to plants
	Promote beneficial organisms that kill pests without harming other species
	Check all plant parts including leaves, stems and especially roots for diseases and insects regularly
	Aerate lawn areas annually
	Reapply mulch as necessary
	Remove dead plant remains regularly
Use landscape materials and equipments efficiently	Collect lawn and garden clippings, pruning waste, tree trimmings, and weeds in order to compost
	Inspect pesticide and fertilizers equipment, irrigation systems and other maintenance equipment periodically
	Check and maintain campus roads, sidewalks, cycle routes, lightings, pools, sculptures, towers, bridges, benches and other furniture regularly
	Train employees and the university community on landscape maintenance
	Monitor and keep records of the maintenance practices applied to campus landscape
To avoid erosion	Avoid loosening the soil when conducting mechanical or manual weed control
To preserve resources	Avoid landscape wastes in and around waterways or storm drainage systems
	Sweep pavement and sidewalk when fertilizer is spilled on these surfaces before applying irrigation water
	Avoid using composting materials exposed to weed killers or systemic insecticides
	Apply pesticides only when wind speeds are low (less than 5 mph) and there is no rain
To use water efficiently	Use automated irrigation systems
	Use popup sprinkler heads in areas with a lot of activity or where there is a chance that pipes may be broken
	Irrigate slowly at rates that do not exceed the infiltration rate of the soil to prevent runoff
	Irrigate in the early morning hours or at night
	Discourage the use of plant species that require frequent maintenance and irrigation
To use fertilizers efficiently	Put fertilizers into the soil rather than dump or broadcast onto the surface
	Test soils periodically for determining proper fertilizer use
	Reduce the use of high nitrogen fertilizers that produce excess growth requiring more frequent mowing or trimming

Table 6.9: Guidelines for Transportation and Parking

Objectives	Actions
To prevent air pollution, greenhouse gas emissions, and noise	Provide good public transport services
	Minimise vehicle usage
	Provide campus shuttle services inside and outside the campus
	Use intercampus shuttle buses powered by electricity or other alternative renewable energy sources
	Promote the use of vehicles with alternative fuels such as electricity or biodiesel
To minimise private car use	Promote ridesharing, carpooling and vanpooling
	Provide privileged parking locations for vans, vehicles for ride-sharing, and buses
To preserve green space	Limit car parking
	Provide underground car parking where available
	Connect high activity nodes, public spaces, sport centres and residential areas in the campus with direct cycling and pedestrian routes, as well as public transport
	Create campus residential areas taking into account walking distances to campus facilities
To limit on campus vehicle parking	Increase parking fees and
	Restrict cars entering to campus
	Facilitate car parking at campus entrances
To prevent heat in parking lots	Increase the amount of shade over paved areas to reduce parking area impact
	Use plantings as buffers to provide visual screening of large areas of parked cars
	Plant trees to lessen microclimatic impact of solar radiation on surfaces of asphalt paving
To control and treat water runoff in parking areas and road surfaces	Design bio swales and rain gardens in car parking
	Use permeable paving materials
	Reduce the amount of paved and impervious surfaces in car parking
To encourage cycling and walking	Design bicycle parking, change/shower and locking facilities for bicyclists
	Provide designated on-site bicycling routes that are user-friendly and mark for visibility
	Connect green spaces with pedestrian routes
	Plant trees to provide shade for pedestrians' comfort
	Create cycling and walking maps, brochures, leaflets etc.
To provide safe bicycle and pedestrian routes	Plan direct, easy connections for pedestrians, cyclists and skaters to avoid any unsafe road crossing
	Separate vehicle, bicycle and pedestrian routes by using plantings
	Provide well lighted, safe and clearly defined pathways across and around the campus for pedestrians

Social dimensions of a sustainable development include population, education, democratization and governance issues. In this part, the subjects such as educational gardens, environmental stewardship and monitoring and sustainability assessment have been considered as the main social criteria of green design in campus landscapes in order to provide environmental awareness and achieve sustainable

development. Higher education institutions can develop environmentally responsible decision-making skills in faculty, staff, students, and community by focusing on green design practices, sustainable campus policies, campus assessments and monitoring, long-term master plans, and a greener curriculum. The guidelines for these criteria are shown in Table 6.10.

Table 6.10: Guidelines for social dimensions of Green Design

Criteria	Actions
Educational gardens	Design and plan demonstration and theme gardens, outdoor classrooms and laboratories, botanical gardens and arboretums
	Display innovative green design techniques such as wind and solar power, usage of recycled materials and other techniques in educational gardens
	Manage the whole campus landscape as an educational area by labelling plants, charting their location, and providing maps
	Use and design natural resources such as forests, rivers, wetlands and geologic formations adjacent or inside the campus area for educational purposes
	Use waterfronts, riversides, creeks, lakes, wetlands as educational areas by providing sidewalks and labels giving information
	Organize open exhibitions and walking tours
	Design botanical gardens and arboretums wherever feasible
	Arrange curriculum and provide courses for the use of educational gardens as environmental awareness and stewardship tool
Environmental Stewardship	Ensure community involvement at all the phases of campus landscape planning by organising meetings, workshops and brainstorming sessions.
	Plan and establish educational reforms in the curriculum
	Consider environmental study programs open to the whole community
	Arrange auditing and monitoring groups involving students, faculty and staff
	Establish relationships with corporations, non-profit organizations, government departments and organizations, other educational institutions and local school districts
	Prepare declarations and action plans to share ideas and to support green design initiatives
	Encourage student projects about green design
	Make internships available to provide a work force for campus facilities and train interns while they contribute to green design activities
	Apply questionnaires and surveys to the university and surrounding community
	Use and prepare websites, TV and radio broadcasts, newsletters, reports and articles about the environmental projects, accomplishments, and plans to promote green design initiatives and sustainability goals
	Design and use campus maps, handbooks, brochures, booklets, posters, stickers with environmental notes on bins, boards and other daily used products to inform people about campus activities, to show examples and to define recyclables
	Support grants and various awards given by the university itself and by profit or non-profit organizations
	Organize competitions, workshops, referendums, conferences, campaigns, forums to provide participation in environmental volunteerism efforts and to encourage community participation in environmental activities.

Table 6.10 continues.

Criteria	Actions
Monitoring and Sustainability Assessment	Develop a specific monitoring plan
	Prepare a timetable setting out targets and performance indicators
	Determine indicators related to policy choices and planning for monitoring
	Adopt indicators that are clear, controllable, measurable, accessible, and consistent.
	Adopt indicators that are comparable with other programmes or plans
	Create a relevant database and keep it updated
	Choose a suitable Campus Sustainability Assessment framework
	Implement Environmental Impact Assessment
	Monitor energy and water consumption, greenhouse gas and other emissions, waste production, use of transportation and car parking, the proportion of re-used, recycled and composted materials, the amount of protected land and green space and landscape maintenance practices in the campus
	Monitor the number of faculty, staff, alumni and students focused on sustainability, annual savings of campus sustainability-related initiatives and funding for sustainability research
	Arrange regular meetings in order to examine progress to date, to identify outstanding tasks and the need for future actions in the campus
	Relate the outcomes of monitoring to decisions regarding future developments

6.3 Green Design Recommendations for Sustainable Development in Yeditepe University Kayisdagi Campus

Yeditepe University Kayisdagi Campus established in 2000 is located in a purpose-built campus at Kayisdagi on the Asian side of Istanbul. Hilly lands of Kayisdagi Campus overlook the city and the Marmara Sea (figure 6.2). The University's name Yeditepe means "Seven Hills" and this refers to the legendary Seven Hills of Istanbul. The campus has original buildings and architecture of the 11th century's old Seljuk style. Seljuk architectural blueprints were applied during planning of Kayisdagi Campus. Double headed eagle and Seljuk pyramids are used at the main campus entrance. The dormitories are built around the faculty and facility buildings based on 1000 year old Turkish Medrese model.

Figure 6.2: General view of Yeditepe University Kayisdagi Campus

The university campus is established on 117,537 m^2 open land, 236,000 m^2 indoor space, 50,000 m^2 green area. The campus contains 7 buildings including faculty and social facility buildings and residence halls (Figure 6.3) (Yeditepe University, 2006).

Yeditepe University Kayisdagi Campus is established at an optimum location in regard to traffic congestions and distance to Istanbul. It is accessible to the city centre from Kayisdagi Campus in 20 minutes with the buses which are operated by the University in every hour.

Figure 6.3: Satellite picture of Kayisdagi Campus (Googleearth, 2006)

Figure 6.4: Kayisdagi Campus entrance and campus roads for vehicles and pedestrians

The Kayisdagi Campus is built on a large green area covered with natural textures. Campus landscape comprises of a forest, recreational areas, sports fields and pedestrian roads. Campus includes fire hydrant system effective to whole site, vehicle and pedestrian roads, canalization, drinking water and drainage systems, which are built compliant to project requirements, contracts and standards.

The outdoor facilities are as follows in the Kayisdagi campus:

- Outdoor basketball, volleyball and tennis courts
- Indoor and outdoor half Olympic sized swimming pools
- 79000 m^2 of open area,
- 50000 m^2 of green area with benches

Campus sits on a 200 meters high hill where North winds dominate. It does not contain windbreaks or shelterbelts created by vegetation, however dormitory buildings located on North side blocks the winds (Figure 6.5).

Figure 6.5: Dormitory buildings in Kayisdagi Campus

Sitting area under pine trees provide shading for campus community (Figure 6.6). On the other hand, vegetation planted along side the pedestrian routes does not provide enough shading for pedestrians.

Figure 6.6: Sitting area under pine trees in Kayisdagi Campus

Kayisdagi Campus does not have a campus landscape plan. It has a site plan demonstrating campus buildings, arboretum, recreational areas, roads and topography of the site (See Appendix B). Landscape planning and maintenance of the campus is executed by Yeditepe University groundskeeping facility and an agricultural technician with the design principles given by the head of Istanbul Education and Culture Foundation. The design principles for Kayisdagi Campus are forming great lawns, protecting trees, creating woodland consisting *Pinus* trees, using an automated irrigation system, natural paving materials and planting ornamental species. As a result of most plants was planted after completion of the construction works without proper soil improvement, plant growth is less healthy than expected (Ata, 2006). Campus groundskeeping facility applies pesticide to campus landscape on demand depending on inspection. However, it does not employ cultural and biological controls. Mulching, pruning, irrigation and hard landscape maintenance are other ongoing periodic maintenance practices. Unfortunately, there is not a regular monitoring exercise in the campus.

Figure 6.7: The Presidency and the Faculty of Economics and Administration Sciences building in Kayisdagi Campus

6.3.1 Current Green Design Applications

However, there are no policies, strategies and plans for sustainability; Kayisdagi Campus has few successful green design applications in campus landscapes such as waste management, automated irrigation systems, and efficient drainage systems. Inside the campus buildings, recycling containers for paper and cardboards have been placed (Figure 6.8). Additionally, there are timers and motion detectors in some campus buildings in order to conserve energy. However, there are not recycling containers and energy efficient lighting in campus landscape.

Figure 6.8: Recycling containers placed in the campus buildings

Campus buildings are located facing east and west and parallel to gradients and contour curves in order to reduce excavation and filling. Most campus building entrances and classrooms are located south and south-east direction in order to get natural lighting. Recently, in some campus buildings motion sensors are being used to conserve energy. Natural gas is being used to provide heating and hot water throughout the campus.

Wastes produced by the campus are grouped as paper, metal, medical, food and other types. Solid Waste Control Regulations are applied to categorize and manage waste in terms of mobility, disposal and for related operations. Any paper or scraps that expired in their product lifecycle are not wasted. Paper waste produced by offices is collected and distributed to recycling facilities. All metal and glass based items are

collected separately in special recycling boxes located throughout the campus. Medical waste produced by the campus is collected by Maltepe Municipality (EIA, 2005).

Water used in day-to-day activities is recycled by Yeditepe University Biologic Waste Water Facility that has an 800 m^3 capacity and supplied back to the campus for landscape irrigation and restroom use. The waste water is filtered in fully automated deposit filters at Biologic Waste Water Facility. After automated filtering, water is re-filtered in carbon filters to be clean from any possible taste, smell, colour, chloral, detergent, petrol and pesticides, asbestos and other organic materials. Chloral solution is given to the water filtered through carbon filters in order to kill pathogenic micro organisms. After these treatment processes, water is aired in the depot. The water which will be reused in campus restrooms is passed to an ultraviolet device. Any mud and mud-like solid waste is processed in a drying unit to produce compost to be used in green fields. With effective use of natural resources and recycling, Yeditepe University does not produce any waste water and water discharge to the outside of the campus site. Surface run-off is managed by an efficient and successful drainage system (EIA, 2005).

The plantings in the Kayisdagi Campus grounds have been protected during the construction phase. Mostly native plants suitable to Istanbul's climate have been used for landscape design. A total of 35,000 m^2 out of 50,000 m^2 of green area is converted to lawns by the implementation of landscape projects. During the construction phase of the campus, the locations of buildings were purposefully considered to protect 10,000 m^2 open space containing *Pinus Maritima* trees. Adjacent to the campus site, undeveloped natural open spaces and woodlands serve as a habitat for plants and animals and provide opportunities for environmental studies and aesthetic enrichment (EIA, 2005). The creek in the campus is covered with cement and being used as road.

Figure 6.9: Vehicle and pedestrian roads in Kayisdagi Campus

Inside the campus shuttle busses taking passengers from the campus entrance to faculty buildings work every ten minutes to avoid vehicle traffic and provide easy accessibility inside the campus (Figure 6.10). Car parking is located under the buildings to maximise open space as landscaped green spaces. There is also an open car parking area located at the campus entrance.

Figure 6.10: Shuttle busses in Kayisdagi Campus

Social activities in Yeditepe University are organized through a large number of student clubs. The University's Nature and TEMA student club tries to build environmental awareness among the campus community. Some of the Yeditepe University students are supporting World Wildlife Fund (WWF) Turkey's nature protection projects voluntarily. Every week in different shopping malls, students open a stand and promote WWF-Turkey's help aided products in order to support forestation and water conservation projects (WWF Turkey, 2005).

Campus includes a vegetable garden planted by gastronomy students (Figure 6.11). The vegetable garden serves as an educational garden for Yeditepe University students (Kozlan, 2006). There are also few sculptures, created by plastic arts students, placed along side the stairs to recreational area (Figure 6.12). There are many other opportunities such as Yeditepe TV, magazine and radio broadcasts in order to improve environmental awareness and stewardship throughout the campus and surrounding community.

Figure 6.11: Vegetable Garden in Kayisdagi Campus (Kozlan, 2006)

Figure 6.12: Sculptures placed along side the stairs to recreational area in Kayisdagi Campus

Yeditepe University has some projects to improve the quality of campus landscape, provide more educational opportunities on campus grounds and consume energy and water. It plans to build a greenhouse on top of its 250 meter square water depot. Besides having a winter garden and plant generation, it will be used for rainwater harvesting (Kozlan, 2006). There is a 7 floor underground parking space and management building project at campus entrance which is currently being used as open parking space (Figure 6.12) in order to meet increasing parking demand (Silahçi, 2006). Additionally, an arboretum project which will be the second in Istanbul has been on going.

Figure 6.13: Open parking space and project area for underground parking space in Kayisdagi Campus

Lack of any arboretum in the Asia side of Istanbul encouraged Yeditepe University to start building Atatürk Arboretum Section of Yeditepe University on a 27 hectare plot in the Kayisdagi site (Figure 6.13). The arboretum aims to serve all students from primary, secondary and high schools in Istanbul and especially for Yeditepe University students. Governance and management of this site will be administered by the General Directorate of Forests, scientific management will be directed by Yeditepe University. Yeditepe University management has made an offer to the General Directorate of Forests about designing the arboretum with the help of Landscape Architecture students and faculty staff in order to provide an educational environment for the University. The arboretum will provide internship opportunities for students.

According to the Report of Arboretum Section Project prepared by Yeditepe University Landscape Architecture Department, the arboretum will include a management building, reception and visitor's area, a lake, nursery, car parking area, geographic sections, amphitheatre, shopping facilities, sculpture garden, and two greenhouses, one is a tropical greenhouse. Landscape design elements such as entrance, patios, roads, boundary elements, terraces, water features, benches, trellis,

wells, as well as drainage, irrigation and lighting projects will be included in the site (Ata, 2003).

Figure 6.14: Atatürk Arboretum Section of Yeditepe University adjacent to Kayisdagi Campus

The irrigation in the arboretum will be provided with soaker hoses in order to avoid excessive water consumption. The water need of the arboretum will be provided by Istanbul Municipality. Additionally, constructing wells near the creek that was covered before are being considered. A lake that includes aquatic plantation will also collect rainwater and stormwater (Ata, 2006).

Arboretum, at the construction phase, has been surrounded by walls bordering residential area. Areas neighbouring to military are bordered by wires. There is no border element built between campus and arboretum. Plants carry labels describing themselves. Nowadays, plantation and plant labelling practices in an area that was damaged by a fire have been ongoing (Figure 6.14).

Figure 6.15: Plant labels in Atatürk Arboretum Section of Yeditepe University

6.3.2 Green Design Recommendations

Yeditepe University Kayisdagi Campus has positive economic, cultural and environmental impacts on its surrounding community. It has some opportunities to be an example of green design implementation and to create better public awareness for the community. As a recommendation, Yeditepe University can establish targets and goals for achieving sustainability in the campus and create a landscape and management plan for its environmental quality. Current green design applications and recommendations for implementing green design in the campus landscape are given in Table 6.11.

Table 6.11: Current Green Design Applications and Green Design Recommendations for Kayisdagi Campus Landscape

Criteria	Current Green Design Applications	Recommendations
Energy Conservation	Building form and orientation Motion detectors and timers inside the buildings	Plant trees for shading
		Create windbreaks or shelterbelts to control wind
		Use energy efficient landscape lighting
		Use renewable energy such as solar and biomass
		Construct green roofs
Waste Management	Solid waste recycling Yeditepe University Biologic Waste Water Facility Wastewater recycling Indoor recycling containers	Use compost and construct on site composting plant
		Arrange outdoor recycling containers at appropriate places
Use of Sustainable Landscape Materials	Native planting Use of natural stones	Use sustainable hard landscape materials
		Use recycled materials
Water Management	Native and non-invasive plants Use of recycled water for landscape irrigation	Create a lake that can collect rainwater runoff
		Collect rainwater and stormwater
		Redesign landscape with less water requirement
Wildlife/Habitat Conservation	Protection of trees during the campus construction Conservation of open natural areas	Daylighting of the creek
		Create a lake
Pest Management	Applying pesticide to campus landscape on demand depending on inspection	Decrease pesticide use, instead use cultural and biological controls
		Use Integrated Pest Management
Landscape Maintenance	Native planting for easy maintenance Mulching, pruning, irrigation and hard landscape maintenance	Improve soil by mulching, using compost, fertilizers
Transportation and Parking	Car parking at the campus entrance Underground car parking Shuttle Buses	Promote public transportation
		Design safe and comfortable pathways for pedestrians
		Promote ridesharing, carpooling and vanpooling
		Provide privileged parking locations for vans, vehicles for ride-sharing, and bus passes
		Use intercampus shuttle buses powered by electricity or other alternative renewable energy sources
		Restrict car entrance to the campus
Environmental Stewardship	Non-profit organizations Student organizations	Educational reforms in curriculum
		Use media to promote green design
		Organise competitions, forums, campaigns
		Arrange student projects, audits, internships
Educational Gardens	Arboretum project Few sculptures Outdoor Classroom	Improve campus landscape for educational use by labeling plants, creating outdoor classrooms
		Create a sculpture garden
		Create demonstration and theme gardens
Monitoring		Monitor regularly
		Determine indicators for monitoring

Use of solar powered lighting features, low voltage lights and motion detectors at Kayisdagi Campus landscape can help to conserve energy. Renewable energy such as solar and biomass energy can be used for the energy need of whole campus. Solar water heating systems and solar panels that convert solar radiation into electricity can be used on the roofs of campus buildings. A biomass-power plant can be constructed in or nearby the campus to convert biomass, which is consists of landscape materials and waste, to other usable forms of energy like methane gas or transportation fuels like ethanol and biodiesel. Campus shuttle buses powered by electricity or other alternative renewable energy sources can be used inside the campus in order to prevent pollution.

The plantation throughout the campus should be designed in order to avoid energy loss in the buildings. Trees should be planted along side the pedestrian pathways in order to provide shade. Windbreaks can be created at the campus locations where wind, noise and dust control is needed in order to provide calm climatic environment comfortable for campus users. Plant types suitable for windbreaks in the campus are chamaecyparis lawsoniana, cupressuss and cupressocyparis leylandii.

Green roofs that minimize the energy loss by insulating the buildings in winter, reduce air conditioning need in summer, absorb rainfall and improve wildlife can be constructed. University can create a lake that works both aesthetically and ecologically. A lake can collect rainwater; provide cooling effect and habitat for wildlife. Rainwater harvesting, the collection and storage of rainwater from roofs, paved surfaces, and the landscape, can be implemented. Rainwater can be collected directly in cisterns or recharged into the ground to improve ground water storage. In order to improve water quality and hydraulic capacity in the campus and surrounding area the culverted creek can be opened with a daylighting project.

Materials which can be re-used and recycled should be considered at landscape design of the campus. Some materials such as recycled plastics, glass, metals, rubber, and paper can be used for decks, fences, pathways, irrigation pipes, insulation, and street furniture such as benches, tables, lightings and planters. Outside recycling containers should be located at appropriate locations in order to collect waste and promote recycling and reusing.

Compost products improve the quality of landscape materials by improving soil and plant fertility, conserving water, lessening landfill impacts, reducing erosion, regulating runoff, and decreasing the dependency on fertilizers and pesticides. Therefore, landscaping wastes such as leaves, grass clippings, plant stalks, vines, weeds, straw, hay, twigs and branches should be collected to be used as compost and an on-site composting facility can be constructed in Kayisdagi Campus. Integrated Pest Management (IPM), based on natural predators, pest-resistant plants, and other cultural and chemical controls should be used in order to preserve a healthy environment and decrease reliance on pesticides in campus landscape.

There is an increasing parking demand in Kayisdagi Campus. Therefore, public transportation, ridesharing, carpooling and vanpooling should be promoted in order to lessen the number of cars traveling to and parking in the campus. Safe and comfortable pathways for pedestrians should be designed in order to encourage walking. Privileged parking locations for vans, vehicles for ride-sharing, and bus passes should be provided. Unfortunately, cycling is not suitable since the campus is on an inclined site. However bicycle parking at the campus entrance can be created for the people traveling to campus by bike.

Educational gardens including demonstration and theme gardens, outdoor classrooms, botanical and horticultural gardens, greenhouses can be created inside the campus. Atatürk Arboretum Section of Yeditepe University will provide an educational environment for the university and surrounding community. The opportunities for internships, trainings, courses, walking tours should be utilized in order to support environmental stewardship and awareness.

Promotion of green design through environmental stewardship by using media, student projects, audits, internships, competitions, forums, campaigns, educational reforms in curriculum, should be considered at Yeditepe University. These activities can provide support for environmental projects, promote environmental stewardship, and help to develop awareness among students, staff, administrators, educators, and local communities while they are participating to green design practices.

The creation of a campus site database through monitoring helps to understand the local mechanisms of the site and gives recorded information for the master plan and

landscape management programs. The indicators for monitoring should be determined for obtaining detailed and comparable scientific results. Indicators give valuable information about the present status of the resources being measured, the rate and direction of change. Therefore, a campus wide monitoring should be implemented in Kayisdagi Campus to be able to establish targets and goals for achieving sustainability in the campus.

CONCLUSION

Climate change, population growth, ozone depletion, land desertification resulting from erosion, deforestation, species decline, and risks of rapid climate change as common environmental problems are growing concerns of contemporary lives for all. Sustainability concept has been arisen from these environmental concerns in order to find long term solutions for environmental degradation. It addresses the question of how societies can reshape their modes of production and consumption habits and balance their needs with nature's capacity in order to conserve environment for future generations. This point of view affected planning and design disciplines as well as new technologies to be compatible with increasing needs on environmental degradation. Campus greening is becoming another significant tool in campus planning influenced by sustainability concept.

'Green Design' term which is commonly used for building design, interior design and use of materials in construction has been interpreted for campus landscape planning in this study. Therefore, social and physical criteria such as energy conservation, waste management, water management, pest management, sustainable landscape material, transportation, wildlife, habitat preservation, landscape maintenance, educational gardens, environmental stewardship and monitoring for green design applications in campus landscapes have been determined to be assessed for this purpose. Each criterion is examined here by providing examples from university campuses to figure out the concept in detail. The green design applications are not all similar in university campuses that are implementing green design for sustainable development. Universities have green design initiatives in different areas. Each criterion defined in this study can be used in order to provide sustainability in university campus landscapes if an integrated green design approach applied.

Universities have pioneer role in teaching and research arena for innovative solutions to society's social, economic and environmental needs. They serve as exemplars of best practice in the management of their resources and wastes, planning, monitoring

and maintenance activities in their areas. They have positive impacts on environmental design in communities of which they are a part. A higher education institution committed to sustainability would help its users and whole community to understand the roots of environmental degradation and motivate them to seek environmentally sustainable practices while also providing opportunities to observe the campus as a model.

The study endeavours to provide flexible design guidelines applicable to almost every university campus landscape based on the design criteria and green design examples from universities across the world. These guidelines aim to guide universities in order to achieve sustainability in their campus landscapes. Each university campus has different natural, social, economic resources and planning history. Accordingly, this study provides a campus planning method applicable to all campuses across the board in a generic framework. However, green design guidelines have been equipped by providing more detailed, goal-oriented activities. These actions may vary in relation to the campuses' social and physical characteristics. In this sense, several actions for greening Yeditepe University Kayisdagi Campus have been recommended. The studies and developments in this campus demonstrate how green design guidelines can be applied to other university campuses. This model is considered as a tool to achieve sustainability in landscape planning for universities within Turkey and across the world.

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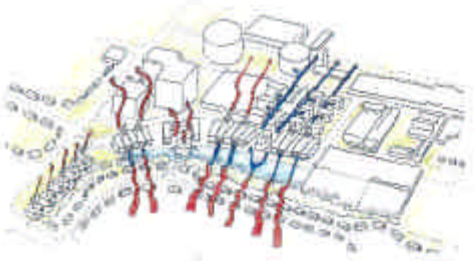
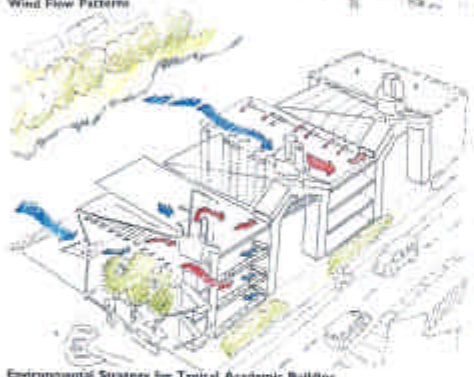


Summer Flow Over the Campus

Wind Flow Patterns

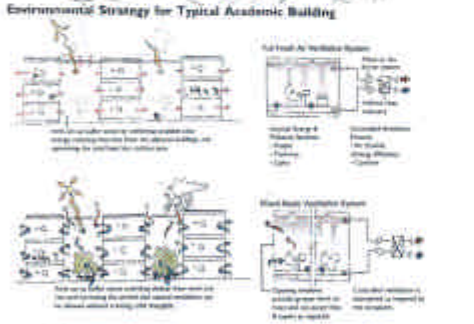
Winter Flow Over the Campus



Environmental Strategy for Typical Academic Building

Water

Summer

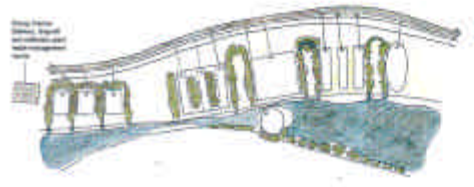


Atrium Ventilation

Winter: 20% of year

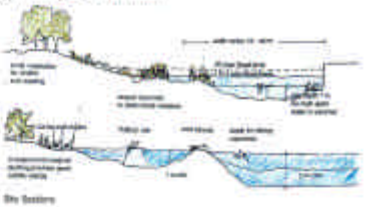
Mid-Season: 60% of year

Summer: 10% of year



Ecological Strategies

Energy Efficiency



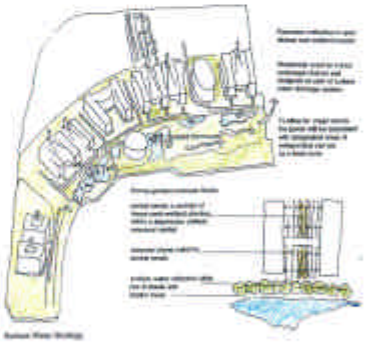
Site Section

Land Balance

Harrier Routes

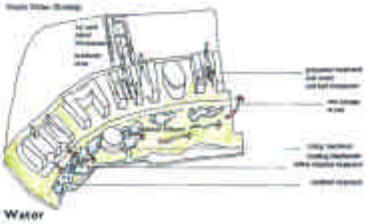
Typical Section Through Lake Showing Proposed Habitat Structure

Landscape



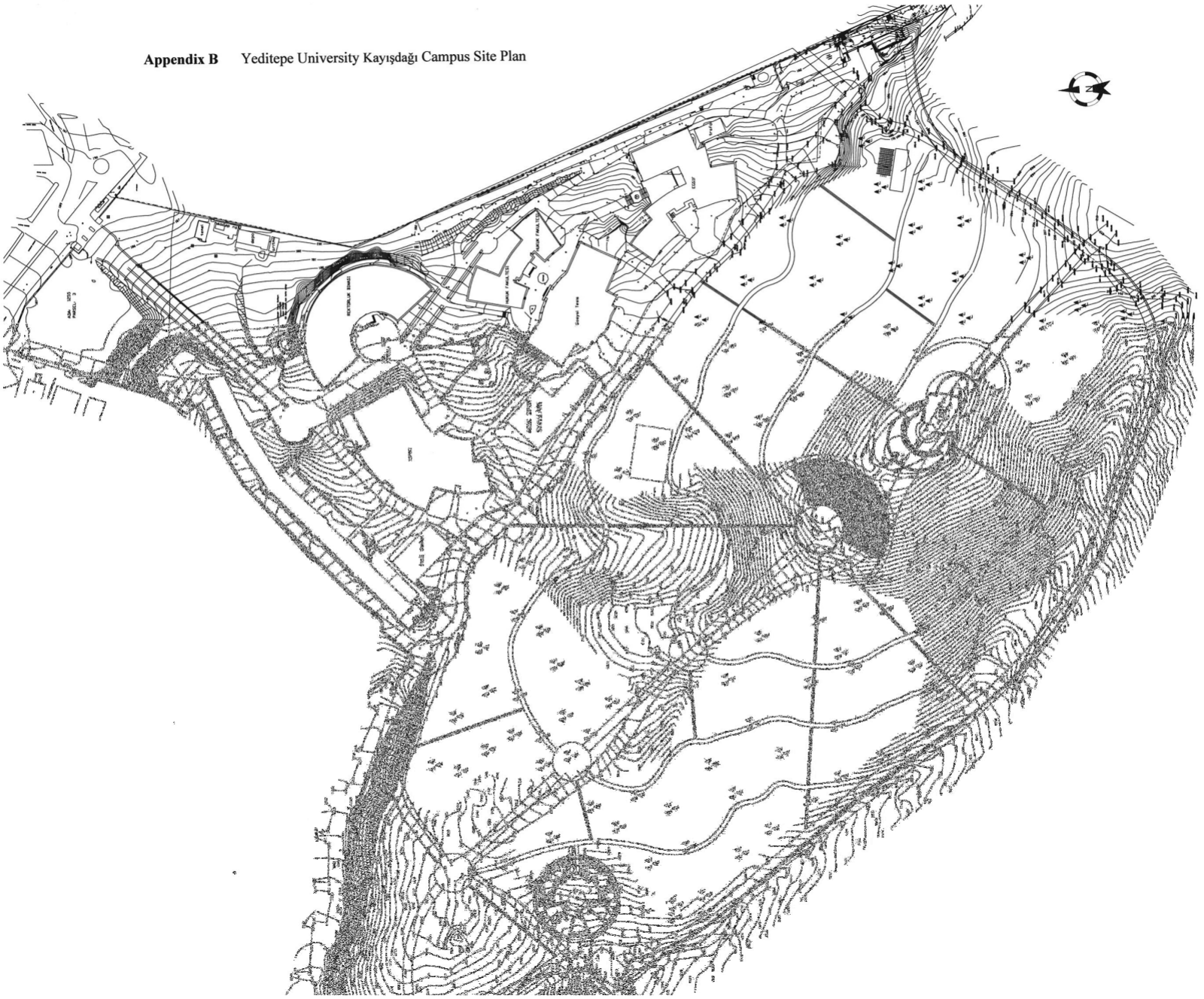
Surface Water Strategy

Waste Water Strategy



Water

Appendix B Yeditepe University Kayışdağı Campus Site Plan



CURRICULUM VITAE

Güliz Tuna was born in Istanbul, Turkey on March 22, 1977. She graduated from Kadiköy Anatolian High School, Istanbul, in 1995. She attended Urban and Regional Planning Program in Mimar Sinan University from 1995 to 1999, and graduated with a Bachelor degree in Urban Planning, in 1999. She was employed as a research assistant in Landscape Architecture Department of Fine Arts Faculty of Yeditepe University for two years. Since 2003 she has been living and working in UK.